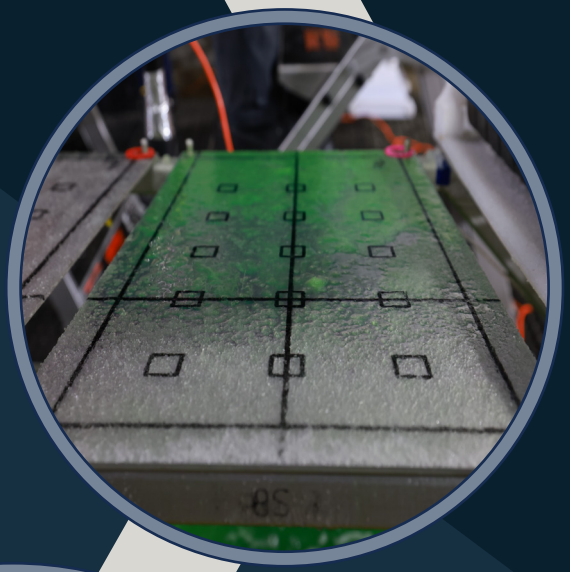
TESTING AND EVALUATION OF MIXED PHASE ICING CONDITIONS: WINTER 2022-23



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In cooperation with:

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William J. Hughes Technical Center

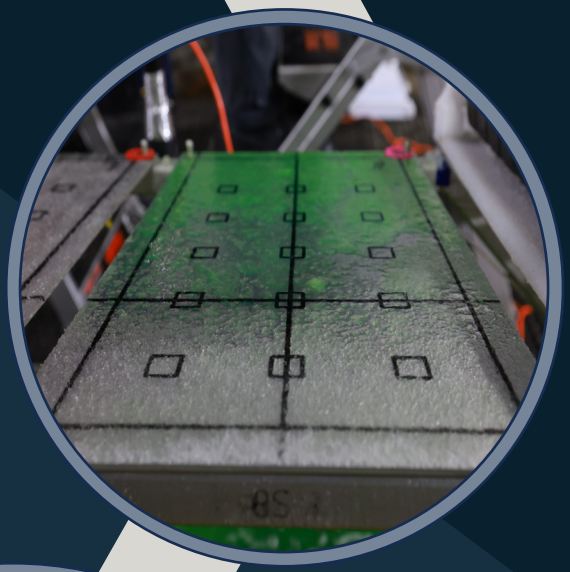
Transport Canada
Civil Aviation

Federal Aviation Administration
Flight Standards – Air Carrier Operations

APS Aviation Inc.

TP 15561E
Final Version 1.0
December 2023

TESTING AND EVALUATION OF MIXED PHASE ICING CONDITIONS: WINTER 2022-23



Prepared by:

Benjamin Bernier

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Un sommaire français se trouve avant la table des matières.

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PREFACE

Under contract to the Transport Canada Programs Group Innovation Centre, APS Aviation Inc. has undertaken a research program to advance aircraft ground de/anti-icing technology. The primary objectives of the research program are the following:

- To develop holdover time data for all new de/anti-icing fluids;
- To evaluate and develop the use of artificial snow machines for holdover time development;
- To conduct wind tunnel testing with a vertical stabilizer common research model to evaluate contaminated fluid flow-off before and after a simulated takeoff;
- To conduct comparative endurance time testing and evaluate endurance times in mixed conditions including snow and freezing fog;
- To conduct general and exploratory de/anti-icing research;
- To conduct analysis to support harmonization of the Transport Canada and the Federal Aviation Administration visibility table guidance;
- To finalize the publication and delivery of current and historical reports;
- To update the regression information report to reflect changes made to the holdover time guidelines; and
- To update the holdover time guidance materials for annual publication by Transport Canada and the Federal Aviation Administration.

The research activities of the program conducted on behalf of Transport Canada during the winter of 2022-23 are documented in five reports. The titles of the reports are as follows:

- TP 15557E Aircraft Ground De/Anti-Icing Fluid Holdover Time Development Program for the 2022-23 Winter;
- TP 15558E Regression Coefficients and Equations Used to Develop the Winter 2023-24 Aircraft Ground Deicing Holdover Time Tables;
- TP 15559E Aircraft Ground Icing General Research Activities During the 2022-23 Winter;
- TP 15560E Wind Tunnel Testing with a Common Research Model Vertical Stabilizer: Winter 2022-23; and
- TP 15561E Testing and Evaluation of Mixed Phase Icing Conditions: Winter 2022-23.

In addition, the following interim report is being prepared:

- *Artificial Snow Research Activities for the 2022-23 Winter*.

This report, TP 15561E, has the following objective:

- To conduct comparative endurance time testing and evaluate endurance times in different mixed phase icing conditions.

This objective was met by conducting endurance time tests with fluids in simulated mixed icing conditions using newly developed test methodologies at the National Research Council Canada Climatic Engineering Facility in Ottawa.

PROGRAM ACKNOWLEDGEMENTS

This multi-year research program has been funded by the Transport Canada Programs Group Innovation Centre, with support from the Federal Aviation Administration William J. Hughes Technical Center, Transport Canada Civil Aviation, and Federal Aviation Administration Flight Standards – Air Carrier Operations. This program could not have been accomplished without the participation of many organizations. APS Aviation Inc. would therefore like to thank Transport Canada, the Federal Aviation Administration, National Research Council Canada, and supporting members of the SAE International G-12 Aircraft Ground Deicing Committees.

APS Aviation Inc. would also like to acknowledge the dedication of the research team, whose performance was crucial to the acquisition of hard data, completion of data analysis, and preparation of reports. This includes the following people: Brandon Auclair, Steven D. Baker, David Beals, Benjamin Bernier, Chloë Bernier, Sarah Chadzak, Brandon Cheer, Devin Costain, John D'Avirro, Christopher D'Avirro, Peter Dawson, Sean Devine, Kyra Kinderman-McCormick, Peter Kitchener, Francine De Ladurantaye, Diana Lalla, Christian Mulligan, Shamim Nakhaei, Sumedha Raj Pilli, Dany Posteraro, Marco Ruggi, Javad Safari, James Smyth, Yi Tian, Jeffrey Wajsberg, Charles Wilson, and Ian Wittmeyer.

Special thanks are extended to Antoine Lacroix, Yvan Chabot, Warren Underwood, Charles J. Enders, Timothy G. Smith, and Andy Pierce who on behalf of Transport Canada and the Federal Aviation Administration, have participated, contributed, and provided guidance in the preparation of these documents.

PROJECT ACKNOWLEDGEMENTS

APS Aviation Inc. would like to acknowledge the team at the National Research Council Canada who operate the Climatic Chamber, especially Medhat Hanna, Luc Levesque, and Richard Lamb; and the fluid manufacturers who have provided samples in support of the testing.

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15. Supplementary Notes (Funding programs, titles of related publications, etc.)

Several research reports for testing of de/anti-icing technologies were produced for previous winters on behalf of Transport Canada (TC). These reports are available from the TC Programs Group Innovation Centre. Several reports were produced as part of this winter's research program. Their subject matter is outlined in the preface. This project was co-sponsored by the Federal Aviation Administration.

16. Abstract

APS Aviation Inc. (APS) carried out research in the winter of 2022-23 in support of the Transport Canada (TC) aircraft ground icing research program. This report documents the evaluation of fluid endurance times in mixed phase icing conditions.

The Type I test results obtained with the updated methodology show that Type I fluid endurance time performance in mixed snow and freezing fog is generally equivalent to its snow-only endurance time performance in corresponding conditions. The results indicate that there may be potential to refine this guidance to provide a greater proportion of the snow-only generic times in conditions of mixed snow and freezing fog for Type I fluids.

Snow-only baseline tests previously conducted in 2021-22 were repeated using a modified methodology. The tests performed using the 2022-23 methodology produced endurance times that were, on average, 15 percent shorter than those performed using the 2021-22 methodology. With further validation, these differences could support revisiting the existing guidance for mixed freezing fog and snow and result in longer holdover times (HOTs) for all fluid types.

Type I fluid performance in mixed snow and rain exceeded that of the rain on a cold-soaked wing baseline in all cases tested. This suggests that the rain on a cold-soaked wing HOTs may be suitable for use with Type I fluids in a mixed snow and rain scenario, however additional data collection should be considered to better characterize this mixed condition. Type II/III/IV fluid performance in mixed snow and rain was somewhat comparable to fluid performance in a rain on a cold-soaked wing condition. Several cases where the performance in the mixed condition fell short of the baseline performance were recorded. Additional data collection is recommended to further characterize this condition prior to guidance development.

Preliminary data indicates that fluid performance in mixed freezing rain and snow is comparable to freezing rain alone (assuming similar liquid water equivalent [LWE] in both cases). There are cases however where the performance in the mixed condition fell short of the baseline performance. Additional data is needed to further characterize this condition for guidance development.

Due the limited data collected for each of the different research goals it was determined that additional data collection should be conducted in the 2023-24 season to validate the findings of the 2022-23 research prior to making changes to the published mixed icing conditions guidance.

It is recommended that additional mixed icing conditions research be conducted next year to collect the necessary data to complete the testing and guidance development objectives begun in 2022-23.

17. Key Words	18. Distribution Statement
Anti-Icing, Holdover Times, Snow, Freezing Fog, Mixed Icing Conditions, Type I, Type II/III/IV, Rain, Freezing Rain	Available from the Transport Canada Programs Group Innovation Centre

19. Security Classification (of this publication)	20. Security Classification (of this page)	21. Declassification (date)	22. No. of Pages	23. Price
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	14. Agent de projet Antoine Lacroix

15. Remarques additionnelles (programmes de financement, titres de publications connexes, etc.)

Plusieurs rapports de recherche sur des essais de technologies de dégivrage et d'antigivrage ont été produits au cours des hivers précédents pour le compte de Transports Canada (TC). Ils sont disponibles auprès du Centre d'innovation du groupe de programmes de TC. De nombreux rapports ont été rédigés dans le cadre du programme de recherche de cet hiver. Leur objet apparaît à l'avant-propos. Ce projet était coparrainé par la Federal Aviation Administration.

16. Résumé

APS Aviation Inc. (APS) a mené des essais au cours de l'hiver 2022-2023 dans le cadre d'un programme de recherche de Transports Canada (TC) sur le givrage d'aéronefs au sol. Le présent rapport fait état de l'évaluation des durées d'endurance des liquides dans des conditions de givrage en phase mixte.

Les résultats des essais sur les liquides de type I obtenus à l'aide de la méthodologie mise à jour indiquent que la performance de la durée d'endurance des liquides de type I en conditions mixtes de neige et de brouillard verglaçant est généralement équivalente à la performance de la durée d'endurance de ces liquides sous neige seulement dans des conditions correspondantes. Les résultats indiquent qu'il pourrait être possible d'ajuster ces lignes directrices afin de fournir une plus grande proportion de durées génériques sous neige seulement en conditions mixtes de neige et de brouillard verglaçant pour les liquides de type I.

Les essais de référence sous neige seulement réalisés auparavant au cours de l'année 2021-2022 ont été répétés au moyen d'une méthodologie modifiée. Les essais effectués au moyen de la méthodologie de 2022-2023 ont généré des durées d'endurance qui étaient, en moyenne, 15 pour cent plus courtes que celles obtenues avec la méthodologie de 2021-2022. Si d'autres travaux de validation sont effectués, ces différences pourraient appuyer la révision des lignes directrices existantes pour les conditions mixtes de neige et de brouillard verglaçant et entraîner des durées d'efficacité prolongées pour tous les types de liquides.

La performance des liquides de type I en conditions mixtes de neige et de pluie a dépassé la performance observée lors des essais de référence en conditions de pluie sur une aile imprégnée de froid dans tous les cas testés. Ces résultats suggèrent que les durées d'efficacité en conditions de pluie sur une aile imprégnée de froid peuvent être utilisées pour des liquides de type I en conditions mixtes de neige et de pluie; il faudrait cependant envisager de recueillir des données supplémentaires afin de mieux caractériser ces conditions mixtes. La performance des liquides de type II/III/IV en conditions mixtes de neige et de pluie était plutôt comparable à la performance des liquides en conditions de pluie sur une aile imprégnée de froid. On a enregistré plusieurs cas où la performance en conditions mixtes n'a pas atteint la performance de référence. Il est recommandé de recueillir des données supplémentaires afin de mieux caractériser ces conditions avant la mise au point de lignes directrices.

Les données préliminaires indiquent que la performance des liquides en conditions mixtes de pluie verglaçante et de neige est comparable à la performance observée en conditions de pluie verglaçante seulement (en supposant une équivalence en eau liquide similaire dans les deux cas). On a enregistré des cas où la performance en conditions mixtes n'a pas atteint la performance de référence. Il est recommandé de recueillir des données supplémentaires afin de mieux caractériser ces conditions avant la mise au point de lignes directrices.

En raison des données limitées recueillies pour chacun des différents objectifs de recherche, il a été déterminé qu'une autre collecte de données devra avoir lieu au cours de la saison 2023-2024 afin de valider les constatations effectuées dans le cadre des recherches menées en 2022-2023 avant d'apporter des modifications aux lignes directrices publiées sur les conditions mixtes de givrage.

Il est recommandé d'effectuer d'autres recherches sur les conditions mixtes de givrage l'année prochaine afin de recueillir les données nécessaires pour atteindre les objectifs relatifs aux essais et à la mise au point de lignes directrices lancés en 2022-2023.

17. Mots clés	18. Diffusion
Antigivrage, durées d'efficacité, neige, brouillard verglaçant, conditions mixtes de givrage, type I, types II/III/IV, pluie, pluie verglaçante	Disponible auprès du Centre d'innovation du groupe de programmes de Transports Canada

19. Classification de sécurité (de cette publication)	20. Classification de sécurité (de cette page)	21. Déclassification (date)	22. Nombre de pages	23. Prix
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EXECUTIVE SUMMARY

Under contract to the Transport Canada (TC) Programs Group Innovation Centre, with support from the Federal Aviation Administration (FAA) William J. Hughes Technical Center, TC Civil Aviation, and FAA Flight Standards – Air Carrier Operations, APS Aviation Inc. (APS) carried out research in the winter of 2022-23 in support of the aircraft ground icing research program.

Each major project completed as part of the 2022-23 research is documented in a separate individual report. This report documents the evaluation of fluid endurance times in mixed phase icing conditions.

Background and Objective

Holdover Time (HOT) guidance is currently provided to industry in the form of generic and fluid-specific guidance tables that provide operators time ranges for safe operation after anti-icing in various environmental conditions. Most of the HOT guidance that is currently published has been developed for conditions where only one precipitation type is present.

One of the primary goals of TC/FAA's ongoing HOT research and development is to maximize operational capabilities for air operators in winter conditions. In recent years, mixed icing conditions has become a research priority to reduce the number of occurrences where operations are restricted by a lack of existing HOT guidance. In 2021-22, APS conducted mixed snow and freezing fog endurance time testing which led to the development of a generic HOT table for use in those conditions. That work was documented in the TC report, TP 15540E, *Evaluation of Fluid Endurance Times in Mixed Snow and Freezing Fog Conditions* (1).

TP 15540E (1) contained a series of recommendations for further mixed icing research, including further testing in mixed snow and freezing fog to refine the available HOT guidance. Also recommended was testing aimed at developing guidance for other mixed icing conditions, including combinations of snow and rain, and snow and freezing rain.

TC and the FAA tasked APS with further developing test methodologies suitable for evaluating anti-icing fluid performance in mixed phase icing conditions, and with conducting testing to obtain the data necessary to support future HOT guidance development for those icing conditions.

Conclusions

The Type I test results obtained with the updated methodology show that Type I fluid endurance time performance in mixed snow and freezing fog is generally equivalent to its snow-only endurance time performance in corresponding conditions. The results indicate that there may be potential to refine this guidance to provide a greater proportion of the snow-only generic times in conditions of mixed snow and freezing fog for Type I fluids.

Snow-only baseline tests previously conducted in 2021-22 were repeated using a modified methodology. The tests performed using the 2022-23 methodology produced endurance times that were, on average, 15 percent shorter than those performed using the 2021-22 methodology. With further validation, these differences could support revisiting the existing guidance for mixed freezing fog and snow and result in longer HOTs for all fluid types.

Type I fluid performance in mixed snow and rain exceeded that of the rain on a cold-soaked wing baseline in all cases tested. This suggests that the rain on a cold-soaked wing HOTs may be suitable for use with Type I fluids in a mixed snow and rain scenario, however additional data collection should be considered to better characterize this mixed condition. Given that the Type I fluid performance varied significantly from the baseline, other potential baselines should be evaluated as well.

The data collected indicates that Type II/III/IV fluid performance in mixed snow and rain is somewhat comparable to fluid performance in a rain on a cold-soaked wing condition. Several cases where the performance in the mixed condition fell short of the baseline performance were recorded. Additional data collection is recommended to further characterize this condition prior to guidance development.

Preliminary data indicates that fluid performance in mixed freezing rain and snow is comparable to freezing rain alone (assuming similar liquid water equivalent [LWE] in both cases). There are cases however where the performance in the mixed condition fell short of the baseline performance. Additional data is needed to further characterize this condition for guidance development.

The results of the mixed icing tests were reviewed and discussed with TC/FAA to determine the best path forward for further mixed icing HOT guidance development.

Due to the limited data collected for each of the different research goals, it was determined that additional data collection should be conducted in the 2023-24 season to validate the findings of the 2022-23 research prior to making changes to the published mixed icing conditions guidance.

Recommendations

It is recommended that additional mixed icing conditions research be conducted next year to collect the necessary data to complete the testing and guidance development objectives begun in 2022-23.

The priorities for mixed icing conditions testing and development in winter 2023-24 have been identified in consultation with TC and the FAA and are listed below.

1. Additional data collection in mixed snow and freezing fog with Type I fluids using the improved snow application methodology.
2. Additional runs of snow-only baseline tests using the test methodology developed in 2022-23 to confirm that the methodology produces repeatable results. If this is the case, consideration should be given to re-evaluating the mixed snow and freezing fog data collected in 2021-22 using the new baseline data.
3. Additional data collection in mixed snow and freezing fog testing at reduced fog rates to characterize the impacts across the full range of precipitation rates and temperatures. In addition, testing in mixed snow and mist (a lower intensity fog spray) will also be considered.
4. Additional data collection in mixed snow and freezing fog with other commercialized fluids to validate the broader applicability of the guidance issued for this condition.
5. Additional data collection in mixed rain and snow to further characterize the condition for guidance development.

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SOMMAIRE

En vertu d'un contrat avec le groupe des programmes du Centre d'innovation de Transports Canada (TC) et avec le soutien du William J. Hughes Technical Center de la Federal Aviation Administration (FAA), du département de l'aviation civile de TC, et de la FAA Flight Standards – Air Carrier Operations, APS Aviation Inc. (APS) a mené des essais au cours de l'hiver 2022-2023 dans le cadre d'un programme de recherche sur le givrage d'aéronefs au sol.

Tous les projets importants achevés dans le cadre du programme de recherche de 2022-2023 sont documentés par l'entremise de rapports individuels. Le présent rapport fait état de l'évaluation des durées d'endurance des liquides dans des conditions de givrage en phase mixte.

Contexte et objectifs

Les lignes directrices relatives aux durées d'efficacité sont actuellement soumises au secteur sous forme de tableaux génériques et de tableaux propres aux liquides qui indiquent aux exploitants les plages d'activité sécuritaires suivant les opérations d'antigivrage dans diverses conditions environnementales. La plupart des lignes directrices sur les durées d'efficacité actuellement publiées ont été élaborées en fonction de conditions où n'intervient qu'un seul type de précipitations.

L'un des objectifs principaux du projet de recherche et développement continus de TC et de la FAA sur les durées d'efficacité est de maximiser les capacités opérationnelles des exploitants aériens dans des conditions hivernales. Ces dernières années, la recherche dans des conditions mixtes de givrage est devenue prioritaire pour réduire le nombre de cas où les opérations sont limitées par l'absence de lignes directrices adaptées à ce contexte. En 2021-2022, APS a mené des essais sur les durées d'endurance en conditions mixtes de neige et de brouillard verglaçant, lesquels ont mené à la mise au point d'un tableau des durées d'efficacité génériques aux fins d'utilisation dans ces conditions. Ces travaux ont été documentés dans le rapport TP 15540E de TC, intitulé *Evaluation of Fluid Endurance Times in Mixed Snow and Freezing Fog Conditions* (1).

Le rapport TP 15540E (1) contenait une série de recommandations pour la réalisation de recherches supplémentaires en conditions mixtes de givrage, y compris la réalisation d'autres essais en conditions mixtes de neige et de brouillard verglaçant, afin de préciser les lignes directrices relatives aux durées d'efficacité existantes. Il recommandait également la réalisation d'essais visant à mettre au point des lignes directrices pour d'autres conditions mixtes de givrage, y compris les conditions mixtes de neige et de pluie, et de neige et de pluie verglaçante.

TC et la FAA ont chargé APS de mettre au point des méthodologies d'essai permettant d'évaluer les performances des liquides d'antigivrage dans des conditions de givrage en phase mixte, et de mener des essais pour recueillir les données nécessaires pour appuyer la mise au point future de lignes directrices relatives aux durées d'efficacité dans ces conditions de givrage.

Conclusions

Les résultats des essais sur les liquides de type I obtenus à l'aide de la méthodologie mise à jour indiquent que la performance de la durée d'endurance des liquides de type I en conditions mixtes de neige et de brouillard verglaçant est généralement équivalente à la performance de la durée d'endurance de ces liquides sous neige seulement dans des conditions correspondantes. Les résultats indiquent qu'il pourrait être possible d'ajuster ces lignes directrices afin de fournir une plus grande proportion de durées génériques sous neige seulement en conditions mixtes de neige et de brouillard verglaçant pour les liquides de type I.

Les essais de référence sous neige seulement réalisés auparavant au cours de l'année 2021-2022 ont été répétés au moyen d'une méthodologie modifiée. Les essais effectués au moyen de la méthodologie de 2022-2023 ont généré des durées d'endurance qui étaient, en moyenne, 15 pour cent plus courtes que celles obtenues avec la méthodologie de 2021-2022. Si d'autres travaux de validation sont effectués, ces différences pourraient appuyer la révision des lignes directrices existantes pour les conditions mixtes de neige et de brouillard verglaçant et entraîner des durées d'efficacité prolongées pour tous les types de liquides.

La performance des liquides de type I en conditions mixtes de neige et de pluie a dépassé la performance observée lors des essais de référence en conditions de pluie sur une aile imprégnée de froid dans tous les cas testés. Ces résultats suggèrent que les durées d'efficacité des liquides de type I en conditions de pluie sur une aile imprégnée de froid peuvent être utilisées en conditions mixtes de neige et de pluie; il faut cependant envisager de recueillir des données supplémentaires afin de mieux caractériser ces conditions mixtes. Étant donné que la performance des liquides de type I différait grandement par rapport aux valeurs de référence, d'autres valeurs de référence potentielles devraient également être évaluées.

Les données recueillies indiquent que la performance des liquides de type II/III/IV en conditions mixtes de neige et de pluie est plutôt comparable à la performance des liquides en conditions de pluie sur une aile imprégnée de froid. On a enregistré plusieurs cas où la performance en conditions mixtes n'a pas atteint la performance de référence. Il est recommandé de recueillir des données supplémentaires afin de mieux caractériser ces conditions avant la mise au point de lignes directrices.

Les données préliminaires indiquent que la performance des liquides en conditions mixtes de pluie verglaçante et de neige est comparable à la performance observée en conditions de pluie verglaçante seulement (en supposant une équivalence en eau liquide similaire dans les deux cas). On a enregistré des cas où la performance en conditions mixtes n'a pas atteint la performance de référence. Il est recommandé de recueillir des données supplémentaires afin de mieux caractériser ces conditions avant la mise au point de lignes directrices.

Les résultats des essais en conditions mixtes de givrage ont fait l'objet d'un examen et d'une discussion de la part de TC et de la FAA afin de déterminer quelle serait la meilleure voie à suivre pour approfondir la mise au point des lignes directrices sur les durées d'efficacité en conditions mixtes de givrage.

En raison des données limitées recueillies pour chacun des différents objectifs de recherche, il a été déterminé qu'une autre collecte de données devra avoir lieu au cours de la saison 2023-2024 afin de valider les constatations effectuées dans le cadre des recherches menées en 2022-2023 avant d'apporter des modifications aux lignes directrices publiées sur les conditions mixtes de givrage.

Recommandations

Il est recommandé d'effectuer d'autres recherches sur les conditions mixtes de givrage l'année prochaine afin de recueillir les données nécessaires pour atteindre les objectifs relatifs aux essais et à la mise au point de lignes directrices lancés en 2022-2023.

Les priorités en matière de recherche et de développement dans des conditions mixtes de givrage au cours de l'hiver 2023-2024 ont été définies de concert avec TC et la FAA, et sont énumérées ci-dessous :

1. Procéder à la collecte de données supplémentaires dans des conditions mixtes de neige et de brouillard verglaçant avec des liquides de type I en utilisant la méthodologie améliorée d'application de neige.
2. Procéder à d'autres essais de référence sous neige seulement en utilisant la méthodologie d'essais mise au point en 2022-2023 afin de confirmer que la méthodologie permet d'obtenir des résultats reproductibles. Si c'est effectivement le cas, envisager de réévaluer les données sur les conditions mixtes de neige et de brouillard verglaçant recueillies en 2021-2022 en utilisant les nouvelles données de référence.
3. Procéder à la collecte de données supplémentaires lors d'essais en conditions mixtes de neige et de brouillard verglaçant, en utilisant des taux de brouillard moindres, afin de caractériser les effets observés pour la gamme complète de taux de précipitation et de températures. En outre, on envisagera également de mener des essais en conditions mixtes de neige et de brume (une vaporisation de brouillard de plus faible intensité).

4. Procéder à la collecte de données supplémentaires en conditions mixtes de neige et de brouillard verglaçant en utilisant d'autres liquides commercialisés afin de valider l'applicabilité à grande échelle des lignes directrices issues de ces conditions.
5. Procéder à la collecte de données supplémentaires en conditions mixtes de pluie et de neige afin de mieux caractériser les conditions et mettre au point des lignes directrices.

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GLOSSARY

APS	APS Aviation Inc.
ARP	Aerospace Recommended Practice
CEF	Climatic Engineering Facility
CSW	Cold-soaked Wing
EG	Ethylene Glycol
ET	Endurance Time
FAA	Federal Aviation Administration
HOT	Holdover Time
LWE	Liquid Water Equivalent
METAR	Meteorological Aerodrome Report
MWG	METAR Working Group
NRC	National Research Council Canada
PG	Propylene Glycol
SAE	SAE International
TC	Transport Canada
YUL	Montréal–Pierre Elliott Trudeau International Airport

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1. INTRODUCTION

Under winter precipitation conditions, aircraft are cleaned prior to takeoff. This is typically done with aircraft ground deicing fluids, which are freezing point depressant fluids developed specifically for aircraft use. If required, aircraft are then protected against further accumulation of precipitation by the application of aircraft ground anti-icing fluids, which are also freezing point depressant fluids. Most anti-icing fluids contain thickeners to extend protection time.

Prior to the 1990s, aircraft ground de/anti-icing had not been extensively researched. However, following several ground icing related incidents in the late 1980s, an aircraft ground icing research program was initiated by Transport Canada (TC). The objective of the program is to improve knowledge, enhance safety, and advance operational capabilities of aircraft operating in winter precipitation conditions.

Since its inception in the early 1990s, the aircraft ground icing research program has been managed by TC, with the co-operation of the United States Federal Aviation Administration (FAA), the National Research Council Canada (NRC), several major airlines, and de/anti-icing fluid manufacturers.

There is still an incomplete understanding of some of the hazards related to aircraft ground icing. As a result, the aircraft ground icing research program continues, with the objective of further reducing the risks posed by the operation of aircraft in winter precipitation conditions.

Under contract to the TC Programs Group Innovation Centre, with support from the FAA William J. Hughes Technical Center, TC Civil Aviation, and FAA Flight Standards – Air Carrier Operations, APS Aviation Inc. (APS) carried out research in the winter of 2022-23 in support of the aircraft ground icing research program. Each major project completed as part of the 2022-23 research is documented in a separate individual report. This report documents the evaluation of fluid endurance times in mixed icing conditions to support guidance development.

1.1 Background

Holdover time (HOT) guidance is currently provided to industry in the form of generic and fluid-specific guidance tables that provide operators with time ranges for safe operation after anti-icing in various environmental conditions. Most of the HOT guidance that is currently published has been developed for conditions where only one precipitation type is present. Meteorological aerodrome report (METAR)–reported weather conditions may not always have a corresponding entry in the HOT guidance to allow for safe departure, and this is especially true for mixed conditions.

One of the primary goals of TC/FAA's ongoing HOT research and development is to maximize operational capabilities for air operators in winter conditions. In recent years, there have been calls from industry to make mixed icing conditions a research priority to reduce the number of occurrences where operations are restricted by a lack of HOT guidance.

A METAR working group (MWG) (consisting of TC/FAA representatives, university-affiliated meteorologists, and industry experts) was formed in 2020-21 with the collective goal of assessing the occurrence of mixed icing conditions in North America and determining which combinations of icing conditions should be prioritized for guidance development. Based on a frequency analysis, mixed snow and freezing fog was identified by the group as the top priority for guidance development. This condition was the focus of a testing session conducted in 2021-22, which led to the development of a generic HOT table for use in mixed snow and freezing fog conditions. This work is documented in the TC report, TP 15540E (1).

TP 15540E (1) contained a series of recommendations for further mixed icing research, including further testing in mixed snow and freezing fog to refine the available HOT guidance. Also recommended was testing aimed at developing guidance for other mixed icing conditions identified by the MWG, including combinations of snow and rain, and snow and freezing rain. Through further consultations with TC and the FAA, a workplan for 2022-23 mixed icing research was developed with the goal of addressing the recommendations from TP 15540E (1), which is discussed in this report.

1.2 Project Objectives

The objectives of this project were as follows:

1) To develop and refine testing methodologies to evaluate anti-icing fluid endurance time performance in mixed icing conditions, including the following:
    a. Moderate rain mixed with snow;
    b. Moderate snow mixed with rain;
    c. Very light or light snow mixed with freezing rain; and
    d. Snow mixed with freezing fog.
2) To conduct testing to collect test data in the above-mentioned conditions; and
3) To analyse the test data collected to evaluate the potential for novel HOT guidance.

The statement of work excerpt for this project is provided in Appendix A.

1.3 Report Format

The following list provides short descriptions of subsequent sections of this report:

a) Section 2 describes the methodologies used to conduct the mixed icing endurance time tests;

b) Section 3 describes data collected during the test session;

c) Section 4 describes the results from the testing, as well as the related guidance development activities;

d) Section 5 provides a summary of the conclusions; and

e) Section 6 provides a summary of the recommendations.

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2. METHODOLOGY

This section provides a brief description of the test methodologies and equipment used during the mixed icing endurance time testing conducted at the NRC Climatic Engineering Facility (CEF).

2.1 Test Location and Schedule

All 2022-23 mixed icing endurance time testing was conducted in simulated conditions at the NRC CEF. Photo 2.1 provides an outdoor view of the facility, giving a general indication of its size (30 m by 5.4 m, height 8 m). The facility was originally designed for the testing of locomotives; Photo 2.2 provides an interior view of the CEF set up for general endurance time testing. The facility is temperature-controlled and equipped with a sprayer system capable of producing multiple types of simulated freezing precipitation.

Testing was conducted over a three-week period beginning on February 27, 2023. The test calendar is shown below in Figure 2.1.

Week of	Sun	Mon	Tue	Wed	Thurs	Fri	Sat
19-Feb-23							
26-Feb-23		Travel to NRC Set-Up Day	R/SN Calibration	R/SN Testing			
5-Mar-23		R/SN Testing	SN/R Testing + ZR/SN Testing	SN/ZF Testing			
12-Mar-23		SN/ZF Testing					
19-Mar-23							

Figure 2.1: NRC CEF Mixed Snow and Freezing Fog Test Calendar

Due to the exploratory nature of the work performed, a daily review discussion was held at the conclusion of each day with TC, the FAA, and APS. During these discussions, the group reviewed the daily test results and discussed the test plan for the following day.

2.2 Mixed Icing Conditions and Sub-Objectives

Several different mixed icing conditions and testing objectives were evaluated during the 2022-23 testing session. The conditions and objectives are described in the following subsections.

2.2.1 Mixed Snow and Freezing Fog Testing

APS conducted endurance time testing in 2022-23 in mixed snow and freezing fog conditions to further advance the work that was begun in 2021-22. This work was subdivided into sub-objectives, which are described in the following subsections.

2.2.1.1 Type I Testing (Improved Methodology)

APS conducted endurance time testing in 2021-22 to develop operational guidance for use of Type I fluids in mixed snow and freezing fog; this work and the recommendations that emerged are documented in TP 15540E (1).

APS developed an improved Type I testing methodology over the course of the 2021-22 test session, where simulated snow application was conducted over one-minute cycles as opposed to the five-minute application cycle used in Type II/III/IV fluid testing. The shorter cycle resulted in a steadier precipitation rate over the test duration, which was deemed necessary to minimize variance in the measured Type I endurance times.

It was recommended that additional data collection be conducted in 2022-23 using the improved testing method to provide the basis for refining the available guidance.

2.2.1.2 Modified Snow-Only Baseline Testing

During the 2021-22 mixed snow and freezing fog testing, snow-only baseline tests were conducted with the fog sprayer in position over the test stand and spraying air (no fog). These snow-only baseline tests were part of the analysis that ultimately led to the publication of generic mixed snow and freezing fog HOT guidance with values set at 50 percent of the generic snow HOT values. This work was documented in TP 15540E (1).

It was recognized during the 2022-23 testing session that the test methodology may have had unintended impacts on the resulting endurance times recorded, as the active air spray was observed to disrupt the spray pattern of the simulated snow during application. Therefore, new snow-only baseline tests with no active air spray from the fog sprayer were conducted to evaluate what effect the previous methodology may have had on the resulting findings and guidance.

2.2.1.3 Testing with Reduced Fog Rates

APS conducted endurance time testing in 2021-22 to develop operational guidance for use of Type II/III/IV fluids in mixed snow and freezing fog; this work and the recommendations that emerged are documented in TP 15540E (1).

During analytical discussions relating to the work conducted in 2021-22, it was suggested that the freezing fog rate of 2 g/dm²/h used in the mixed condition tests that formed the basis of the resulting HOT guidance may be overly conservative when compared to typical freezing fog rates experienced in operations.

One recommendation that emerged from TP 15540E (1) was to conduct additional tests with Type II/III/IV fluids in mixed snow and freezing fog with a reduced freezing fog rate of 1 g/dm²/h to assess the differing impact of lower-rate fog in the mixed condition, with the end goal of refining the HOT guidance for this condition.

2.2.1.4 Heavy Snow Rate Testing

Following review of the 2021-22 test results and consultations with TC and the FAA, a generic mixed snow and freezing fog HOT table was created for publication in the 2022-23 TC/FAA HOT Guidelines.

One limitation of the resulting guidance table was the requirement that operators use the table in conjunction with the TC/FAA "Snowfall Intensities as a Function of Prevailing Visibility" tables. No HOTs are provided for mixed snow and freezing fog if use of the visibility tables prescribes a "Heavy" snowfall intensity.

Due to the obscuring nature of fog, most cases where fog and snow are reported in tandem will result in a reported visibility corresponding to the "Heavy" snowfall intensity classification in the visibility tables (even if the true snowfall intensity is moderate or lighter), which results in no HOT guidance being available.

One recommendation that emerged from TP 15540E (1) was to develop a modified mixed snow and freezing fog test protocol that incorporated higher rates of snow to characterize the impacts of added freezing fog in a heavy snow scenario.

This work was exploratory in nature and was not expected to produce guidance for 2022-23, as several other operational considerations exist for operations in heavy snow that were not yet addressed.

2.2.2 Mixed Snow and Rain Testing

In the winter of 2008-09, APS conducted research to develop HOT guidance for conditions of light snow mixed with rain. This was achieved by conducting tests in mixed light snow and rain conditions; the resulting endurance times were found to be comparable to light freezing rain endurance times, and guidance was issued allowing the use of light freezing rain HOTs in conditions of light snow mixed with rain. This work is documented in the TC report, TP 14936E, *Aircraft Ground Icing General Research Activities During the 2008-09 Winter* (2).

As there is currently no HOT guidance available for conditions of moderate snow mixed with rain (and moderate rain mixed with snow), it was recommended that APS conduct endurance time testing in 2022-23 in mixed snow and rain conditions to support the objective of HOT guidance development for this mixed condition. This included evaluation of both "Moderate Snow and Rain" and "Moderate Rain and Snow" conditions in different rate combinations, differentiated by which of the two precipitation types predominates.

2.2.3 Mixed Freezing Rain and Snow Testing

In the winter of 2008-09, APS conducted research to develop HOT guidance for conditions of light snow mixed with rain. This was achieved by conducting tests in mixed light snow and rain conditions; the resulting endurance times were found to be comparable to light freezing rain endurance times, and guidance was issued allowing the use of light freezing rain HOTs in conditions of light snow mixed with rain. This work is documented in TP 14936E (2).

As there is currently no HOT guidance available for conditions of freezing rain mixed with snow, it was recommended that APS conduct preliminary endurance time testing in 2022-23 in mixed freezing rain and snow conditions to see if light freezing rain HOTs would be suitable for use in a mixed freezing rain and snow condition.

2.3 Test Procedure

To satisfy the project objectives, fluid endurance time tests were conducted in a variety of simulated precipitation conditions. Fluid thickness, fluid Brix, and plate temperature measurements were collected at regular intervals during the test runs.

The general test procedure is included in Appendix B. This procedure includes details regarding the test objectives, test plan, test setup, test methodologies, test equipment used, fluids used, and other pertinent information and documentation.

The general APS methodology for endurance time testing in simulated freezing precipitation conditions is included in Appendix C. The test setup used for this project deviated from the standard setup used in freezing precipitation HOT testing in the following ways:

1) Canopy tents were installed beside the test stands to shield the snow dispenser equipment from the freezing fog, freezing rain, and non-freezing rain spray; and
2) The two test stands were oriented such that the higher edges of each plate were in the middle of the setup to ensure that the snow-dispensing process was equivalent on each stand.

The general testing setup is depicted in Photo 2.3. A view of the test stand during application of contamination is depicted in Photo 2.4.

2.4 Simulated Precipitation and Rate Calibration

The following types of precipitation were simulated for the endurance time testing in the NRC CEF:

- Snow;
- Freezing Fog;
- Freezing Rain; and
- Rain.

2.4.1 Simulated Snow

Simulated snow consists of small ice crystals measuring less than 1.4 mm in diameter. Previous testing conducted by APS investigated the dissolving properties of the artificial snow versus natural snow. The artificial snow produced by this method was selected as an appropriate substitute for natural snow.

The snow was manufactured inside the cooled test chamber. Cubes of ice were crushed and passed through calibrated sieves (see Photo 2.5) to obtain the required ice crystal size range. Hand-held motorized dispensers (seen in Photo 2.3) were used to dispense the snow during testing.

2.4.2 Simulated Freezing and Non-Freezing Drizzle, Rain, and Fog Precipitation

The conditions of freezing and non-freezing fog, rain, and drizzle are simulated using an NRC-developed sprayer assembly providing a large scan area and appropriate spray uniformity over the test area. The scanner consists of a horizontal main shaft supported by two bearings. The actual spray head assembly is shaft-mounted on a rotating scanner so that one scan covers a lateral running strip of the test area. A stepper motor is synchronized to index the relative angle of the spray head between scans along an axis perpendicular to the scan axis. This provides two axes of rotation, essentially an x-y plane, one along each axis. Each scan is consecutively indexed to complete the precipitation coverage of the test bed area. This defines one cycle of the spray unit. The scan rate, index angle, and the number of scans per cycle are adjusted, along with the fluid delivery pressures (water and compressed air), to obtain appropriate droplet sizes and precipitation rates through selected nozzles. The sprayer assembly is shown in Photo 2.6.

2.4.3 HOT Precipitation Rates

The rate limits defined for standard HOT testing were referenced to determine appropriate precipitation rates for the different mixed icing combinations evaluated during the test session. Figure 2.2 demonstrates the relevant HOT testing precipitation rate limits for the precipitation types used in the testing:

- Freezing Fog: 2-5 g/dm²/h;
- Freezing Drizzle: 5-13 g/dm²/h;
- Freezing Rain: 13-25 g/dm²/h;
- Light Snow: 4-10 g/dm²/h;
- Moderate Snow: 10-25 g/dm²/h;
- Heavy Snow: >25 g/dm²/h; and
- Rain (Cold-Soaked Wing): 5-75 g/dm²/h.

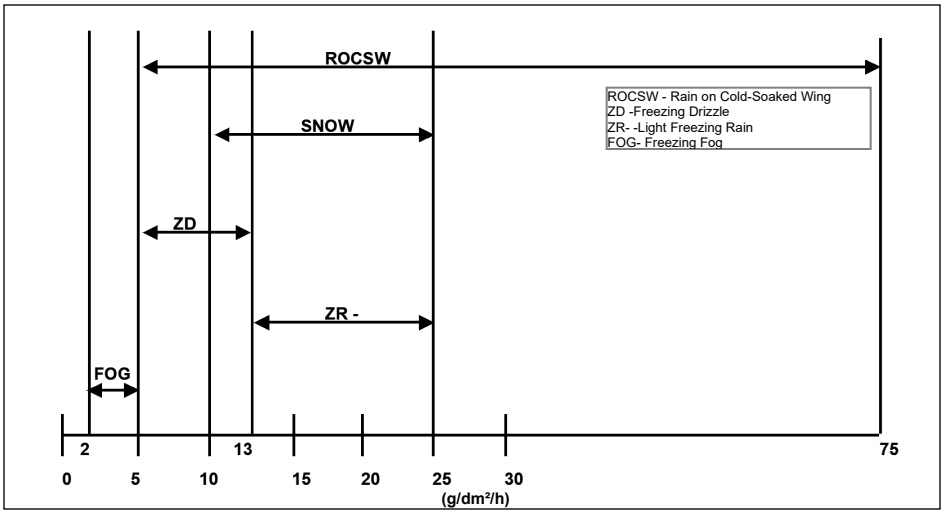


Figure 2.2: HOT Precipitation Rate Limits

2.4.4 Comparative Test Groupings

For each of the research objectives evaluated, the endurance time tests performed were grouped to allow for comparative assessment of the effects of different precipitation type and rate combinations.

2.4.4.1 Mixed Snow and Freezing Fog Test Groupings

For the mixed snow and freezing fog research, snow-only tests are used as the baseline tests as snow is typically the predominant precipitation in the mixed condition. Additionally, snow HOTs are a more conservative baseline as they are generally shorter than freezing fog HOTs for a given fluid.

The test groupings for the Type I testing with the improved methodology are shown in Figure 2.3.

The test groupings for the reduced fog rate testing are shown in Figure 2.4. For this research objective, all tests apart from the "Snow 10+ Freezing Fog 1" were previously completed in 2021-22.

The test groupings for the heavy snow rate testing are shown in Figure 2.5.

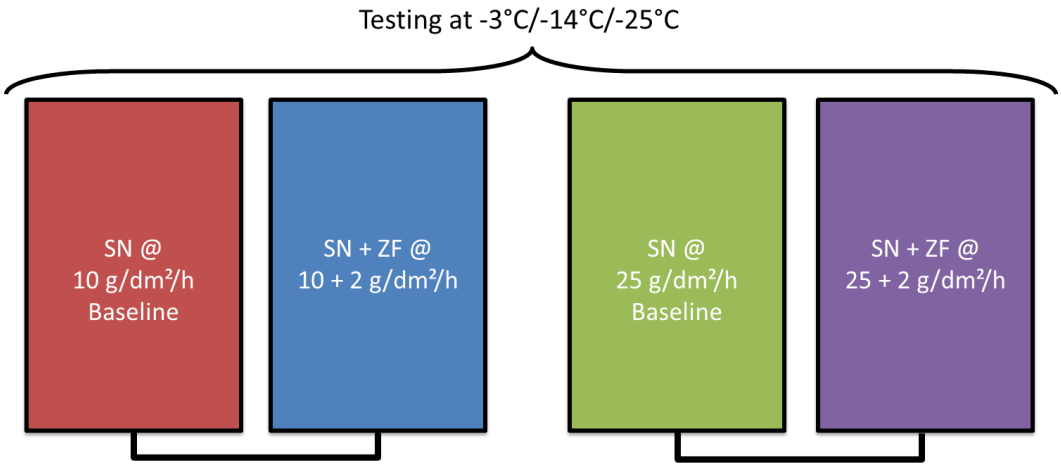


Figure 2.3: Test Groupings – Improved Type I Testing

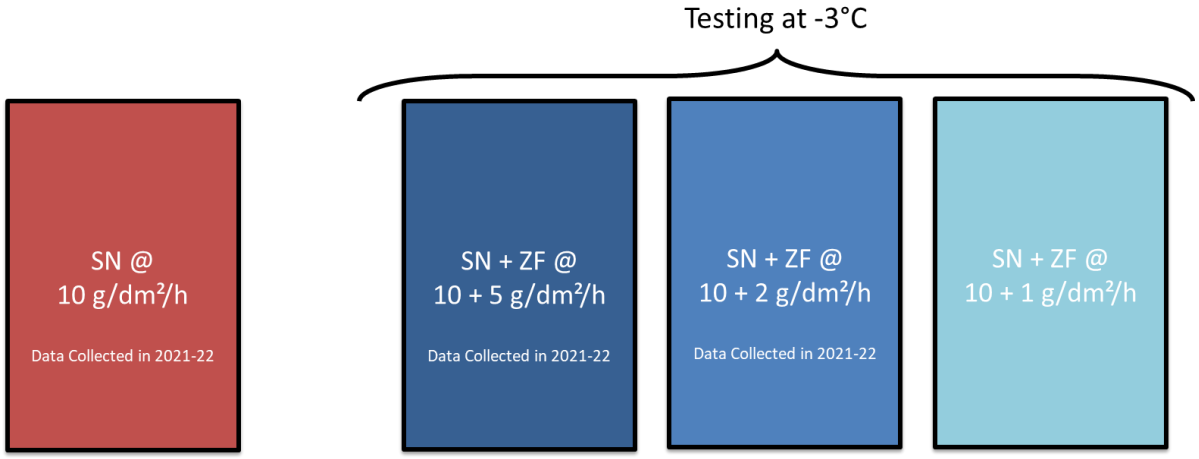


Figure 2.4: Test Groupings – Reduced Fog Rate Testing

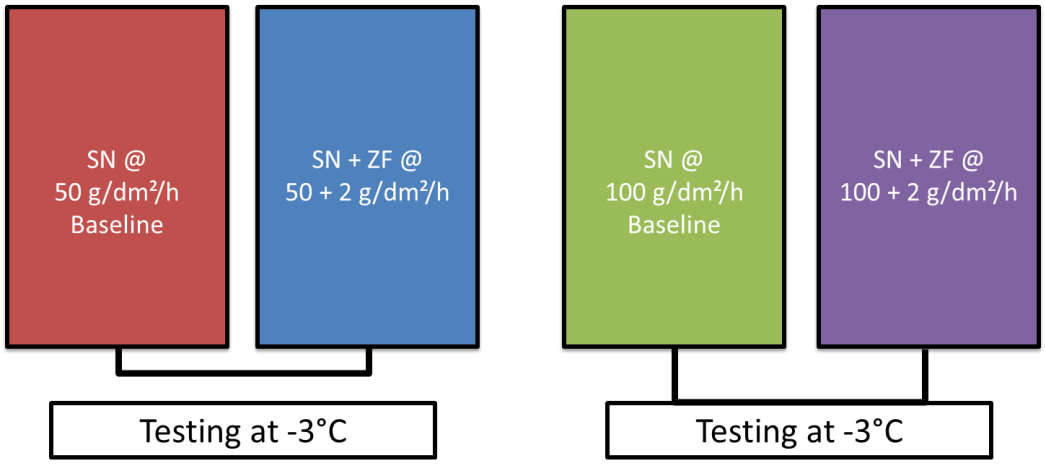


Figure 2.5: Test Groupings – Heavy Snow Rate Testing

2.4.4.2 Mixed Snow and Rain Test Groupings

The test groupings for mixed snow and rain are shown below in Figure 2.6. The test groupings for mixed rain and snow are shown below in Figure 2.7.

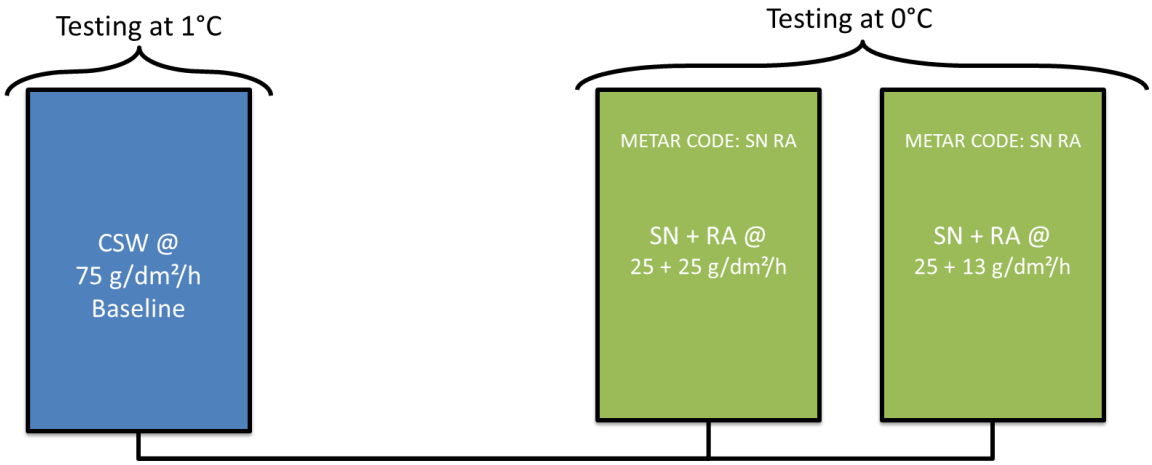


Figure 2.6: Test Groupings – Mixed Snow and Rain Testing

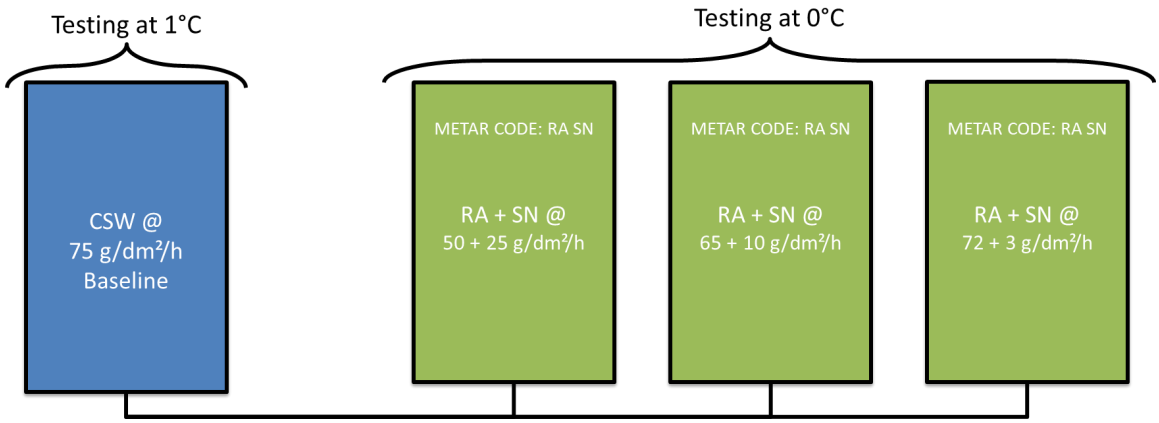


Figure 2.7: Test Groupings – Mixed Rain and Snow Testing

During the initial planning for the mixed icing test session, the baseline condition for the mixed snow and rain tests was expected to be light freezing rain (as indicated in the test procedure). During the test session, however, it was determined that rain on a cold-soaked wing (CSW) would be a better baseline due to the similarity in overall precipitation rate at the high end (the precipitation rate for the HOT condition ranges from 5-75 g/dm²/h).

Multiple different combinations of rain and snow rates were evaluated to allow for better characterization of fluid performance in this mixed icing condition.

2.4.4.3 Mixed Freezing Rain and Snow Test Groupings

The test groupings for the mixed freezing rain and snow tests are depicted below in Figure 2.8.

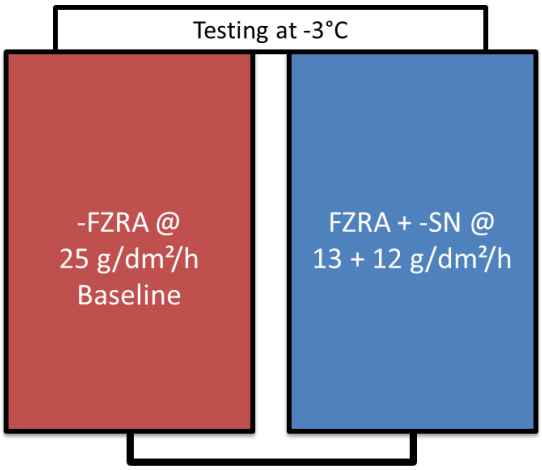


Figure 2.8: Test Groupings – Mixed Freezing Rain and Snow Testing

Freezing rain was used as the baseline condition for the mixed freezing rain and snow tests as the freezing rain HOTs are generally more conservative than the snow HOTs for a given fluid at a specific precipitation rate.

2.4.5 Precipitation Rate Calibration and Rate Measurement

This subsection describes the precipitation rate calibration activities conducted prior to and during the test session at the NRC CEF, as well the methods employed for determining test precipitation rates during the testing session.

2.4.5.1 Snow Rate Calibration

The simulated snow production and distribution methodology that was used in this comparative test methodology is not typically used during standard HOT testing. As such, significant effort went into calibrating the application process to ensure repeatability of the test results.

Snow rate calibration was achieved through dry runs (no fluid applied) where known snow masses were applied to the test surfaces over a fixed period. The resulting precipitation rates were subsequently calculated for each position on the test stand using the measured change in mass to confirm that the achieved rates were in line with the targeted rate for the tests being performed and that the rate variability from position to position was also acceptable.

Initial calibration testing was first performed in 2021-22 in a refrigerated trailer at the APS test site near the Montréal–Pierre Elliott Trudeau International Airport (YUL) in Montreal, Quebec, in the weeks leading up to the NRC CEF test session. These initial trials involved dispensing known snow masses onto testing stands outfitted with collection pans and configured in the same manner as during the actual testing session. The collection pans were weighed before and after the application process, and the resulting test rates were recorded. The simulated snow was manufactured using the same process employed during the test session and was applied using the same snow-dispensing equipment and dispenser configuration as during the testing. The preliminary snow calibration trials are depicted in Photo 2.7.

The results of the preliminary trials were used to set the initial snow mass needed to achieve the target snow rates in the test plan. Prior to beginning the endurance time tests, snow calibration runs were performed in the testing chamber at the NRC CEF to validate the targets established during the preliminary calibration trials. During these runs, it was determined that minor adjustments to the snow masses assigned to the snow dispensers were necessary to achieve the target snow rates evenly across both test stands within the CEF test chamber. Adjustments were made until a run with satisfactory rates across all positions was observed.

To determine the test rates during snow-only tests, rate collection pans were left on the corner positions of each test stand during testing. At the conclusion of the test run (once all plates on the stands had failed), the rates accumulated in the four pans were calculated. The average rate of the four corner pan rates was then used as the test rate for each of the tests conducted on the stands.

The test stand setup (with rate pans installed on the corners) is depicted in Photo 2.8.

2.4.5.2 Rain and Freezing Precipitation Rate Calibration

Simulated freezing fog, freezing rain, and non-freezing rain were created using the same NRC sprayer assembly that is used to generate these conditions in standard HOT testing. As such, the rate calibration processes employed were the same as those employed during a standard HOT test session. These calibration processes are described in detail within the SAE International (SAE) Aerospace Recommended Practice (ARP) 5485B, *Endurance Time Test Procedures for SAE Type II/III/IV Aircraft Deicing/Anti-Icing Fluids* (3).

Described briefly, the process is as follows: the test stands were positioned in the testing chamber, equipped with pre-weighed rate collection pans, and subsequently exposed to the simulated precipitation spray for a known period. The pans were then weighed again, and the precipitation rate was calculated for each testing position. Following this, adjustments to the flow rate of the precipitation were made if the rates were found to be outside of the tolerance limits associated with the target rate being simulated (and the process was repeated).

To determine the test rates for the freezing fog-only tests, two cycles of approximately 10-minute rates were measured on each position on the test stand using the above process both before and after the endurance time test. The test rate is the average of the four rates measured in this process.

2.4.5.3 Mixed Snow and Rain or Freezing Precipitation Rate Calibration

To determine the impact that the simulated rain or freezing precipitation had on the simulated snow application, additional mixed condition rate calibration runs were performed.

To calibrate the combined precipitation, the freezing precipitation/rain spray was first activated, and the freezing precipitation or rain rates were measured and calibrated to the desired target level. Once the desired rate was achieved, rate collection pans were installed on the test stands and known snow masses were applied for a fixed period. The resulting precipitation rates were subsequently calculated for each position on the test stand using the measured change in mass to confirm that the achieved rates were in line with the targeted rate for the tests being performed and that the rate variability from position to position was also acceptable.

Analysis of the early combined calibration run results indicated that further adjustments to the snow quantities dispensed would be necessary on a run-by-run basis to offset the impact of the downwash from the rain or fog precipitation spray (which frequently resulted in a top stand and bottom stand differential).

Due to the need to vary the snow quantities from the pre-calibration targets depending on the conditions of a given test, it was determined that all mixed precipitation test runs would be preceded by rate validation to ensure that the target rates were being achieved.

To determine the overall test rates for the mixed condition tests, rate collection pans were left on the corner positions of each test stand during the test. At the conclusion of the test run (once all plates on the stands had failed), the rates accumulated in the four pans were calculated. The average rate of the four corner pan rates was then used as the test rate for each of the tests conducted on the stands. The individual snow rates were determined by subtracting the average rain/freezing precipitation rates measured prior to snow application from the overall test rate.

2.5 Photography and Videography

Videography of the test runs was captured using tripod-mounted video cameras. One video camera was mounted on each side of the stands used for testing, and each test run was recorded from fluid application to fluid failure.

In addition to the videography, photography depicting fluid failure was also captured for each individual test poured. General testing and setup photos were also captured during the test runs.

Due to the large amount of data available, photos of the individual tests have not been included in this report, but the high-resolution photos and video have been provided to TC in electronic format and can be made available upon request.

2.6 Personnel

Four APS staff members were required on site to conduct the tests, and five additional APS support staff from Ottawa were tasked to manufacture and dispense snow as well as to help with general setup tasks. A professional photographer was retained to coordinate photography and videography of the test runs. Representatives from TC and the FAA provided direction in testing during daily conference meetings.

2.7 Data Forms

An endurance time testing data form was used to record the results of the endurance time tests. An additional data form was used to calculate and log the necessary snow quantities for each test run. Copies of these forms are provided in the test procedure, which is included in Appendix B.

2.8 Fluids

Six fluids were used in the mixed icing testing conducted in 2022-23. The fluids used and the measured viscosity (using the manufacturer method) are described below:

- Dow Chemical Company UCAR™ PG Type I Aircraft Deicing Fluid Concentrate, a propylene glycol–based Type I fluid (viscosity not measured);
- ChemR EG Type I Concentrate, an ethylene glycol–based Type I fluid (viscosity not measured);

- Clariant Safewing MP II Flight, a propylene glycol–based Type II fluid (measured viscosity 13,520 cP);
- AllClear Systems AeroClear MAX, an ethylene glycol–based Type III fluid (measured viscosity 17,000 cP);
- Cryotech Deicing Technology Polar Guard® Advance, a propylene glycol–based Type IV fluid (measured viscosity 14,820 cP); and
- Dow Chemical Company UCAR™ Endurance EG106 De/Anti-Icing Fluid, an ethylene glycol–based Type IV fluid (measured viscosity 39,500 cP).

These fluids were chosen to allow for a broad assessment of the effects of combining snow and freezing fog across a range of different fluid types and fluid bases.

The Type I fluid was prepared in batches from concentrate, with each batch being diluted to the appropriate concentration to ensure a consistent 10°C buffer between the test temperature and the fluid freezing point.

The Type II, Type III, and Type IV fluids used were all undiluted, mid-production viscosity samples.

Photo 2.1: Outside View of the NRC CEF

Photo 2.2: Inside View of the NRC CEF Control Room

Photo 2.3: NRC CEF Cold Chamber and General Mixed Condition Testing Setup

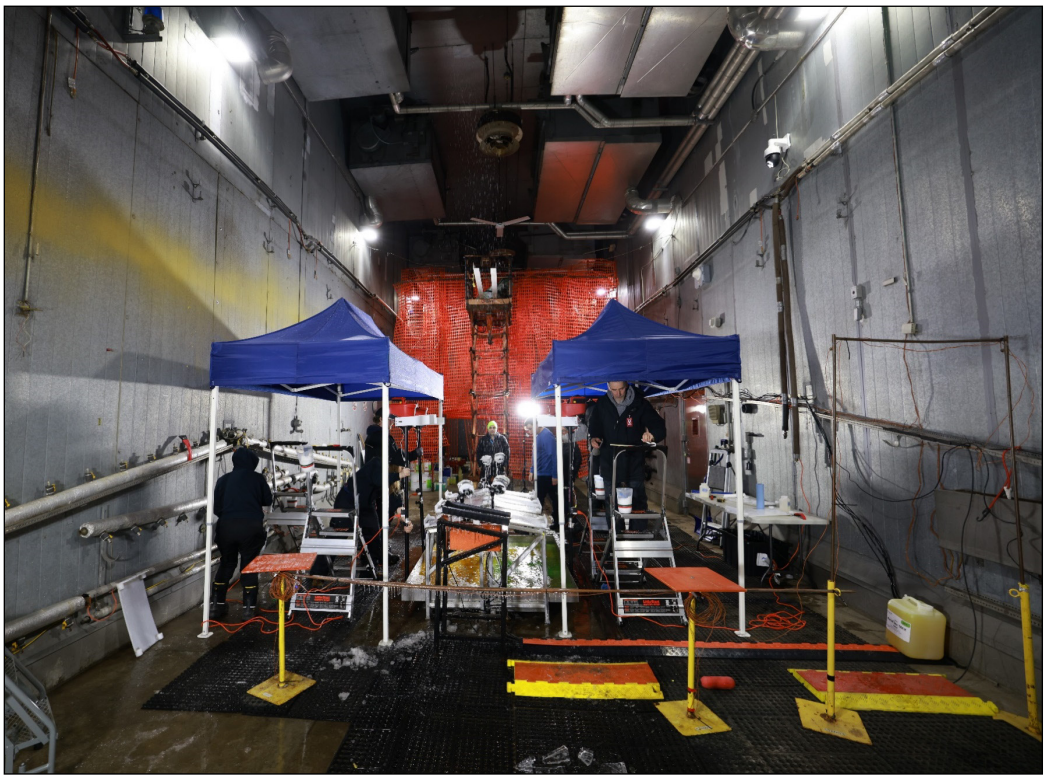


Photo 2.4: Test Stand View During Contamination

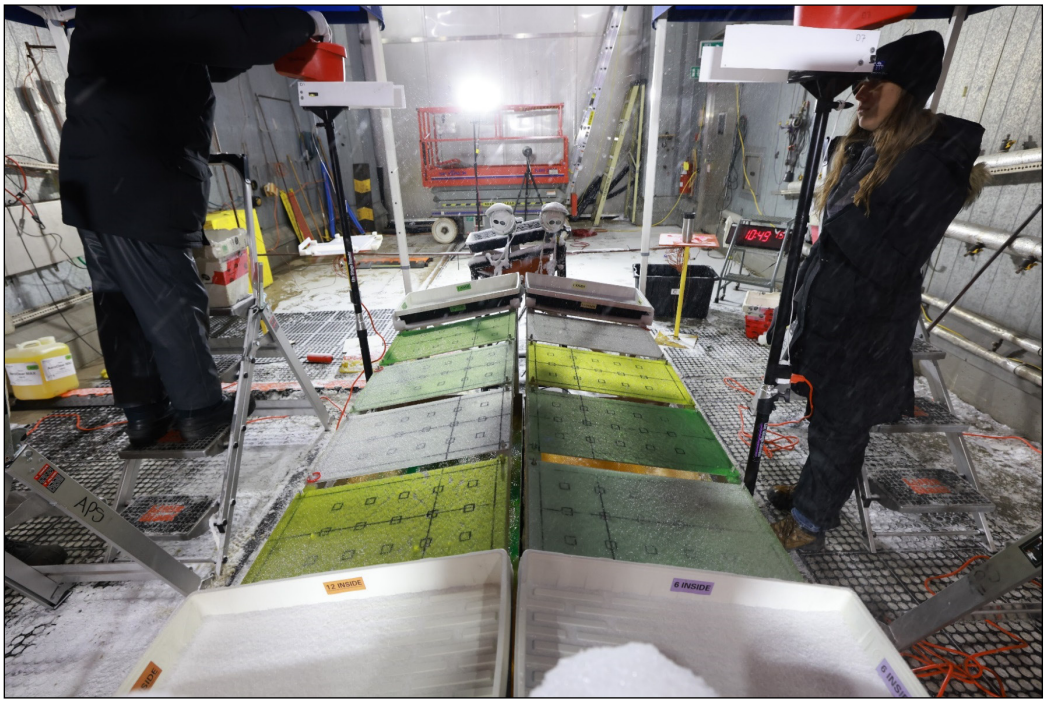


Photo 2.5: Calibrated Sieves Used to Obtain Desired Snow Size Distribution

Photo 2.6: NRC Sprayer Assembly

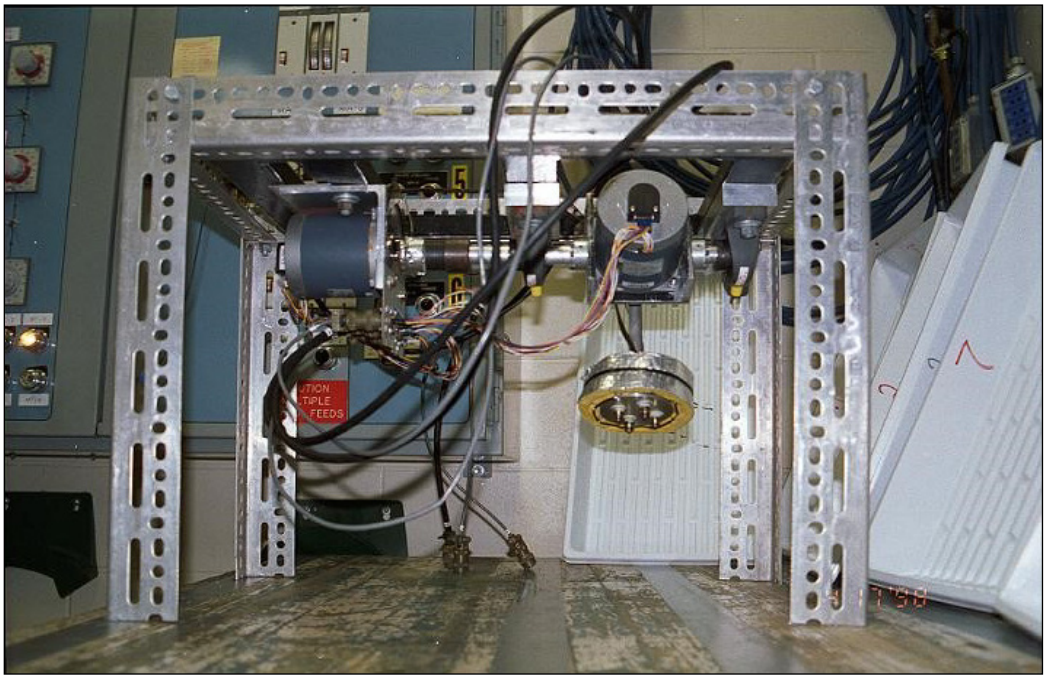


Photo 2.7: Pre-Testing Snow Calibration Trials

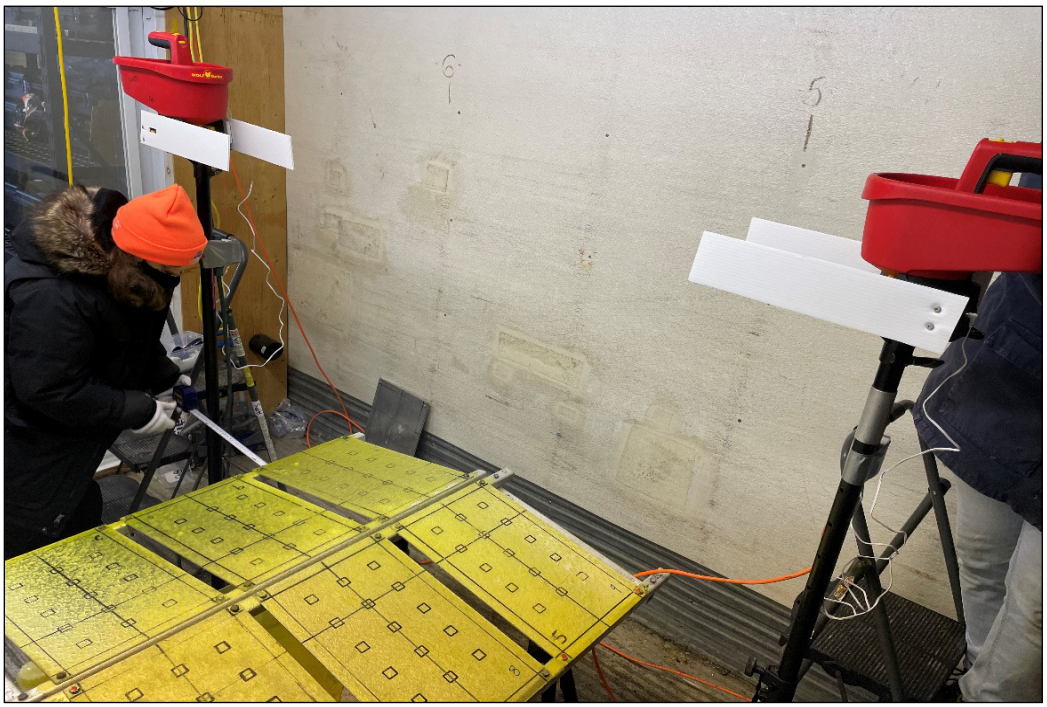


Photo 2.8: Mixed Conditions Test Stand with Rate Pans on Corner Positions

3. DATA – NRC CEF TESTING

This section contains the details on the testing data obtained during the mixed icing endurance time testing conducted at the NRC CEF in 2022-23.

3.1 2021-22 Test Data

The modified snow-only baseline research sub-objective makes reference to test data collected during in 2021-22. The relevant test data from the 2021-22 mixed icing research endurance time testing has been included with this report in Appendix D.

3.2 2022-23 Test Logs

A total of 328 endurance time tests were conducted at the NRC CEF, broken down by condition as follows:

- 164 tests were conducted to evaluate conditions of snow mixed with freezing fog;
- 148 tests were conducted to evaluate conditions of snow mixed with rain (or rain mixed with snow); and
- 16 tests conducted to evaluate conditions of snow mixed with freezing rain.

Table 3.1 contains a brief description of each of the column headings found in the test logs. The tests conducted at the NRC CEF during the winter of 2022-23 have been included in three separate logs:

- Table 3.2 contains the details of all tests conducted in 2022-23 to evaluate conditions of snow mixed with freezing fog; details from an additional 12 tests conducted in 2021-22 that are relevant to the analysis conducted in 2022-23 have also been included for reference;
- Table 3.3 contains the details of all tests conducted in 2022-23 to evaluate conditions of snow mixed with rain (or rain mixed with snow); and
- Table 3.4 contains the details of all tests conducted in 2022-23 to evaluate conditions of snow mixed with freezing rain.

These logs provide relevant information for each of the tests, as well as final values used for the data analysis. Each row contains data specific to one test.

Table 3.1: Description of Column Headings in the NRC CEF Testing Logs

Column Heading	Description
Test #	The number assigned in the test plan to identify the test run.
Date	The date when the test was conducted.
Fluid Name	The name of the anti-icing fluid used during the test.
Fluid Type	The type of the anti-icing fluid used during the test.
Test Surface	The material of which the test surface is composed.
Condition	The precipitation type(s) being simulated during the test.
Testing Sub-Objective	The sub-objective that the test was conducted to evaluate (snow and freezing fog tests only).
Temp. (°C)	The chamber temperature setting during the test.
Target Combined Rate (g/dm²/h)	The targeted rate of all components of the precipitation combined.
Actual Rate (Snow Only – g/dm^2/h)	The measured rate of the snow component of the precipitation alone.
Actual Rate (Other Precipitation Only – g/dm^2/h)	The measured rate of the rain or freezing precipitation component of the precipitation.
Actual Rate (Combined – g/dm^2/h)	The measured rate of all components of the precipitation combined.
Endurance Time (min)	The measured endurance time of the test.
Adjusted Endurance Time (min)	The measured endurance time of the test after adjustment to account for rate variations relative to the target rate.

When conducting comparative tests, it is necessary to adjust the measured endurance times to compensate for variations in precipitation rates within the individual tests. For the tests in Table 3.2, Table 3.3, and Table 3.4, this was done by adjusting the measured endurance time for each test by a linear ratio, which is determined by the average rate of precipitation (combined or individual) measured over the course of each individual test as compared to the targeted rate of the baseline test. The endurance times were adjusted based on a linear relationship with the following formula:

$$Adjusted\ Endurance\ Time = Actual\ Endurance\ Time\ x \quad \frac{Actual\ Rate\ of\ Precipitation}{Target\ Rate\ of\ Precipitation}$$

These adjustments were made to allow for the direct comparison of tests with the same target combined rate of precipitation.

Table 3.2: Test Log – Mixed Snow and Freezing Fog Endurance Time Testing at the NRC CEF

Test #	Date	Fluid Name	Fluid Type	Test Surface	Condition	Testing Sub-Objective	Temp. (°C)	Target Combined Rate (g/dm²/h)	Actual Rate (Snow Only)	Actual Rate (Freezing Fog Only)	Actual Rate (Combined)	Endurance Time (min)	Adjusted Endurance Time (min)
0-151A	8-Mar-22	Dow PG ADF Concentrate	I	Aluminum	Light Snow	Type I Testing (Improved Methodology)	-3	10	10.5	-	-	**8.5**	**8.9**
0-152A	8-Mar-22	Dow PG ADF Concentrate	I	Aluminum	Light Snow	Type I Testing (Improved Methodology)	-3	10	10.5	-	-	**8.5**	**8.9**
0-159A	8-Mar-22	Dow PG ADF Concentrate	I	Composite	Light Snow	Type I Testing (Improved Methodology)	-3	10	10.5	-	-	**4.4**	**4.6**
0-160A	8-Mar-22	Dow PG ADF Concentrate	I	Composite	Light Snow	Type I Testing (Improved Methodology)	-3	10	10.5	-	-	**4.4**	**4.6**
0-269A	11-Mar-22	Dow PG ADF Concentrate	I	Aluminum	Light Snow	Type I Testing (Improved Methodology)	-14	10	11.3	-	-	**5.9**	**6.7**
0-270A	11-Mar-22	Dow PG ADF Concentrate	I	Aluminum	Light Snow	Type I Testing (Improved Methodology)	-14	10	11.3	-	-	**6.2**	**7.1**
0-277A	11-Mar-22	Dow PG ADF Concentrate	I	Composite	Light Snow	Type I Testing (Improved Methodology)	-14	10	11.3	-	-	**3.5**	**4.0**
0-278A	11-Mar-22	Dow PG ADF Concentrate	I	Composite	Light Snow	Type I Testing (Improved Methodology)	-14	10	11.3	-	-	**4.8**	**5.4**
0-1115A	8-Mar-22	Dow PG ADF Concentrate	I	Aluminum	Light Snow and Freezing Fog	Type I Testing (Improved Methodology)	-3	12	-	-	12.5	**8.3**	**8.6**
0-1116A	8-Mar-22	Dow PG ADF Concentrate	I	Aluminum	Light Snow and Freezing Fog	Type I Testing (Improved Methodology)	-3	12	-	-	12.5	**8.0**	**8.3**
0-1117A	8-Mar-22	Dow PG ADF Concentrate	I	Composite	Light Snow and Freezing Fog	Type I Testing (Improved Methodology)	-3	12	-	-	12.5	**4.8**	**5.0**
0-1118A	8-Mar-22	Dow PG ADF Concentrate	I	Composite	Light Snow and Freezing Fog	Type I Testing (Improved Methodology)	-3	12	-	-	12.5	**4.5**	**4.6**
1	15-Mar-23	Dow PG ADF Concentrate	I	Aluminum	Light Snow	Type I Testing (Improved Methodology)	-3	10	10.3	0	10.3	**5.5**	**5.6**
3	15-Mar-23	Dow PG ADF Concentrate	I	Composite	Light Snow	Type I Testing (Improved Methodology)	-3	10	10	0	10	**3.8**	**3.8**
5	15-Mar-23	CHEMR REG I	I	Aluminum	Light Snow	Type I Testing (Improved Methodology)	-3	10	9.3	0	9.3	**6.4**	**6.0**
7	15-Mar-23	CHEMR REG I	I	Composite	Light Snow	Type I Testing (Improved Methodology)	-3	10	9.9	0	9.9	**4.3**	**4.3**
9	15-Mar-23	Dow PG ADF Concentrate	I	Aluminum	Moderate Snow	Type I Testing (Improved Methodology)	-3	25	26.3	0	26.3	**4.1**	**4.3**

Table 3.2: Test Log – Mixed Snow and Freezing Fog Endurance Time Testing at the NRC CEF (cont'd)

Test #	Date	Fluid Name	Fluid Type	Test Surface	Condition	Testing Sub-Objective	Temp. (°C)	Target Combined Rate (g/dm²/h)	Actual Rate (Snow Only)	Actual Rate (Freezing Fog Only)	Actual Rate (Combined)	Endurance Time (min)	Adjusted Endurance Time (min)
11	15-Mar-23	Dow PG ADF Concentrate	I	Composite	Moderate Snow	Type I Testing (Improved Methodology)	-3	25	28.3	0	28.3	**2.2**	**2.5**
13	15-Mar-23	CHEMR REG I	I	Aluminum	Moderate Snow	Type I Testing (Improved Methodology)	-3	25	23	0	23	**4.2**	**3.9**
15	15-Mar-23	CHEMR REG I	I	Composite	Moderate Snow	Type I Testing (Improved Methodology)	-3	25	25.3	0	25.3	**2.3**	**2.4**
17	14-Mar-23	Dow PG ADF Concentrate	I	Aluminum	Light Snow	Type I Testing (Improved Methodology)	-14	10	8.6	0	8.6	**3.3**	**2.8**
19	14-Mar-23	Dow PG ADF Concentrate	I	Composite	Light Snow	Type I Testing (Improved Methodology)	-14	10	9.2	0	9.2	**2.2**	**2.0**
21	14-Mar-23	CHEMR REG I	I	Aluminum	Light Snow	Type I Testing (Improved Methodology)	-14	10	8.9	0	8.9	**3.1**	**2.7**
23	14-Mar-23	CHEMR REG I	I	Composite	Light Snow	Type I Testing (Improved Methodology)	-14	10	10.2	0	10.2	**2.2**	**2.2**
25	14-Mar-23	Dow PG ADF Concentrate	I	Aluminum	Moderate Snow	Type I Testing (Improved Methodology)	-14	25	26.1	0	26.1	**2.1**	**2.1**
27	14-Mar-23	Dow PG ADF Concentrate	I	Composite	Moderate Snow	Type I Testing (Improved Methodology)	-14	25	23.9	0	23.9	**1.3**	**1.2**
29	14-Mar-23	CHEMR REG I	I	Aluminum	Moderate Snow	Type I Testing (Improved Methodology)	-14	25	22.2	0	22.2	**3.2**	**2.8**
31	14-Mar-23	CHEMR REG I	I	Composite	Moderate Snow	Type I Testing (Improved Methodology)	-14	25	23.7	0	23.7	**1.3**	**1.2**
33	13-Mar-23	Dow PG ADF Concentrate	I	Aluminum	Light Snow	Type I Testing (Improved Methodology)	-25	10	10.2	0	10.2	**1.3**	**1.3**
35	13-Mar-23	Dow PG ADF Concentrate	I	Composite	Light Snow	Type I Testing (Improved Methodology)	-25	10	10.2	0	10.2	1.1	1.1
37	13-Mar-23	CHEMR REG I	I	Aluminum	Light Snow	Type I Testing (Improved Methodology)	-25	10	10.2	0	10.2	1.8	1.9
39	13-Mar-23	CHEMR REG I	I	Composite	Light Snow	Type I Testing (Improved Methodology)	-25	10	10.2	0	10.2	1.3	1.3
41	13-Mar-23	Dow PG ADF Concentrate	I	Aluminum	Moderate Snow	Type I Testing (Improved Methodology)	-25	25	25.7	0	25.7	0.9	0.9
43	13-Mar-23	Dow PG ADF Concentrate	I	Composite	Moderate Snow	Type I Testing (Improved Methodology)	-25	25	25.7	0	25.7	1.3	1.3
45	13-Mar-23	CHEMR REG I	I	Aluminum	Moderate Snow	Type I Testing (Improved Methodology)	-25	25	25.7	0	25.7	1.1	1.1

Table 3.2: Test Log – Mixed Snow and Freezing Fog Endurance Time Testing at the NRC CEF (cont'd)

Test #	Date	Fluid Name	Fluid Type	Test Surface	Condition	Testing Sub-Objective	Temp. (°C)	Target Combined Rate (g/dm²/h)	Actual Rate (Snow Only)	Actual Rate (Freezing Fog Only)	Actual Rate (Combined)	Endurance Time (min)	Adjusted Endurance Time (min)
47	13-Mar-23	CHEMR REG I	I	Composite	Moderate Snow	Type I Testing (Improved Methodology)	-25	25	25.7	0	25.7	0.8	0.9
49	16-Mar-23	Dow PG ADF Concentrate	I	Aluminum	Light Snow and Freezing Fog	Type I Testing (Improved Methodology)	-3	12	8.9	2.3	10.6	6.2	5.5
51	16-Mar-23	Dow PG ADF Concentrate	I	Composite	Light Snow and Freezing Fog	Type I Testing (Improved Methodology)	-3	12	9.4	2.2	11.4	3.9	3.7
53	16-Mar-23	CHEMR REG I	I	Aluminum	Light Snow and Freezing Fog	Type I Testing (Improved Methodology)	-3	12	10.1	2	12.2	6.4	6.5
55	16-Mar-23	CHEMR REG I	I	Composite	Light Snow and Freezing Fog	Type I Testing (Improved Methodology)	-3	12	10.5	2.1	12.2	4.7	4.8
57	16-Mar-23	Dow PG ADF Concentrate	I	Aluminum	Moderate Snow and Freezing Fog	Type I Testing (Improved Methodology)	-3	27	27	2.3	29.3	3.7	4.0
59	16-Mar-23	Dow PG ADF Concentrate	I	Composite	Moderate Snow and Freezing Fog	Type I Testing (Improved Methodology)	-3	27	28.5	2.2	30.7	2.4	2.7
61	16-Mar-23	CHEMR REG I	I	Aluminum	Moderate Snow and Freezing Fog	Type I Testing (Improved Methodology)	-3	27	27.2	2	29.2	5.2	5.6
63	16-Mar-23	CHEMR REG I	I	Composite	Moderate Snow and Freezing Fog	Type I Testing (Improved Methodology)	-3	27	24.6	2.1	26.7	3.2	3.1
65	14-Mar-23	Dow PG ADF Concentrate	I	Aluminum	Light Snow and Freezing Fog	Type I Testing (Improved Methodology)	-14	12	9	2.1	11.1	3.0	2.8
67	14-Mar-23	Dow PG ADF Concentrate	I	Composite	Light Snow and Freezing Fog	Type I Testing (Improved Methodology)	-14	12	8.7	2.5	11.2	2.2	2.1
69	14-Mar-23	CHEMR REG I	I	Aluminum	Light Snow and Freezing Fog	Type I Testing (Improved Methodology)	-14	12	8.6	2.4	11	3.0	2.8
71	14-Mar-23	CHEMR REG I	I	Composite	Light Snow and Freezing Fog	Type I Testing (Improved Methodology)	-14	12	9.5	2.1	11.6	2.1	2.0
73	14-Mar-23	Dow PG ADF Concentrate	I	Aluminum	Moderate Snow and Freezing Fog	Type I Testing (Improved Methodology)	-14	27	27	2.3	29.3	**2.1**	**2.3**
75	14-Mar-23	Dow PG ADF Concentrate	I	Composite	Moderate Snow and Freezing Fog	Type I Testing (Improved Methodology)	-14	27	28.5	2.2	30.7	**1.1**	**1.3**
77	14-Mar-23	CHEMR REG I	I	Aluminum	Moderate Snow and Freezing Fog	Type I Testing (Improved Methodology)	-14	27	27.2	2	29.2	**2.2**	**2.3**
79	14-Mar-23	CHEMR REG I	I	Composite	Moderate Snow and Freezing Fog	Type I Testing (Improved Methodology)	-14	27	24.6	2.1	26.7	**1.5**	**1.5**
81	13-Mar-23	Dow PG ADF Concentrate	I	Aluminum	Light Snow and Freezing Fog	Type I Testing (Improved Methodology)	-25	12	9.6	2.3	11.9	**1.4**	**1.4**

Table 3.2: Test Log – Mixed Snow and Freezing Fog Endurance Time Testing at the NRC CEF (cont'd)

Test #	Date	Fluid Name	Fluid Type	Test Surface	Condition	Testing Sub-Objective	Temp. (°C)	Target Combined Rate (g/dm²/h)	Actual Rate (Snow Only)	Actual Rate (Freezing Fog Only)	Actual Rate (Combined)	Endurance Time (min)	Adjusted Endurance Time (min)
83	13-Mar-23	Dow PG ADF Concentrate	I	Composite	Light Snow and Freezing Fog	Type I Testing (Improved Methodology)	-25	12	9.8	2.2	12	**1.1**	**1.1**
85	13-Mar-23	CHEMR REG I	I	Aluminum	Light Snow and Freezing Fog	Type I Testing (Improved Methodology)	-25	12	9.9	1.9	11.8	**1.2**	**1.2**
87	13-Mar-23	CHEMR REG I	I	Composite	Light Snow and Freezing Fog	Type I Testing (Improved Methodology)	-25	12	10	2.1	12.1	**1.4**	**1.4**
89	13-Mar-23	Dow PG ADF Concentrate	I	Aluminum	Moderate Snow and Freezing Fog	Type I Testing (Improved Methodology)	-25	27	24.1	2.3	26.4	**1.1**	**1.1**
91	13-Mar-23	Dow PG ADF Concentrate	I	Composite	Moderate Snow and Freezing Fog	Type I Testing (Improved Methodology)	-25	27	27.5	2.2	29.7	**1.0**	**1.2**
93	13-Mar-23	CHEMR REG I	I	Aluminum	Moderate Snow and Freezing Fog	Type I Testing (Improved Methodology)	-25	27	22.9	2	24.9	**1.1**	**1.0**
95	13-Mar-23	CHEMR REG I	I	Composite	Moderate Snow and Freezing Fog	Type I Testing (Improved Methodology)	-25	27	27.1	2.1	29.2	**1.0**	**1.0**
105	16-Mar-23	Clariant Safewing MP II FLIGHT	II	Aluminum	Moderate Snow and Freezing Fog	Reduced Fog Rate Testing	-3	11	-	-	11.2	**109.5**	**111.5**
106	16-Mar-23	Clariant Safewing MP II FLIGHT	II	Aluminum	Moderate Snow and Freezing Fog	Reduced Fog Rate Testing	-3	11	-	-	11.2	**112.8**	**114.9**
107	16-Mar-23	AllClear AeroClear MAX	III	Aluminum	Moderate Snow and Freezing Fog	Reduced Fog Rate Testing	-3	11	-	-	11.2	**37.7**	**38.3**
108	16-Mar-23	AllClear AeroClear MAX	III	Aluminum	Moderate Snow and Freezing Fog	Reduced Fog Rate Testing	-3	11	-	-	11.2	**42.3**	**43.0**
109	16-Mar-23	Cryotech Polar Guard Advance	IV	Aluminum	Moderate Snow and Freezing Fog	Reduced Fog Rate Testing	-3	11	-	-	11.2	**128.0**	**130.4**
110	16-Mar-23	Cryotech Polar Guard Advance	IV	Aluminum	Moderate Snow and Freezing Fog	Reduced Fog Rate Testing	-3	11	-	-	11.2	**110.1**	**112.1**
111	16-Mar-23	Dow EG106	IV	Aluminum	Moderate Snow and Freezing Fog	Reduced Fog Rate Testing	-3	11	-	-	11.2	**96.1**	**97.9**
112	16-Mar-23	Dow EG106	IV	Aluminum	Moderate Snow and Freezing Fog	Reduced Fog Rate Testing	-3	11	-	-	11.2	**83.1**	**84.6**
169	8-Mar-23	Dow PG ADF Concentrate	I	Aluminum	Heavy Snow	Heavy Snow Rate Testing	-3	50	51.6	0	51.6	**1.4**	**1.4**
171	8-Mar-23	Dow PG ADF Concentrate	I	Composite	Heavy Snow	Heavy Snow Rate Testing	-3	50	51.6	0	51.6	**1.2**	**1.2**
173	8-Mar-23	CHEMR REG I	I	Aluminum	Heavy Snow	Heavy Snow Rate Testing	-3	50	51.6	0	51.6	**2.1**	**2.2**

Table 3.2: Test Log – Mixed Snow and Freezing Fog Endurance Time Testing at the NRC CEF (cont'd)

Test #	Date	Fluid Name	Fluid Type	Test Surface	Condition	Testing Sub-Objective	Temp. (°C)	Target Combined Rate (g/dm²/h)	Actual Rate (Snow Only)	Actual Rate (Freezing Fog Only)	Actual Rate (Combined)	Endurance Time (min)	Adjusted Endurance Time (min)
175	8-Mar-23	CHEMR REG I	I	Composite	Heavy Snow	Heavy Snow Rate Testing	-3	50	51.6	0	51.6	**1.5**	**1.5**
177	8-Mar-23	Clariant Safewing MP II FLIGHT	II	Aluminum	Heavy Snow	Heavy Snow Rate Testing	-3	50	51.6	0	51.6	**18.1**	**18.7**
178	8-Mar-23	Clariant Safewing MP II FLIGHT	II	Aluminum	Heavy Snow	Heavy Snow Rate Testing	-3	50	51.6	0	51.6	**18.2**	**18.7**
179	8-Mar-23	AllClear AeroClear MAX	III	Aluminum	Heavy Snow	Heavy Snow Rate Testing	-3	50	51.6	0	51.6	**19.5**	**20.1**
180	8-Mar-23	AllClear AeroClear MAX	III	Aluminum	Heavy Snow	Heavy Snow Rate Testing	-3	50	51.6	0	51.6	**20.1**	**20.8**
181	8-Mar-23	Cryotech Polar Guard Advance	IV	Aluminum	Heavy Snow	Heavy Snow Rate Testing	-3	50	51.6	0	51.6	**21.0**	**21.7**
182	8-Mar-23	Cryotech Polar Guard Advance	IV	Aluminum	Heavy Snow	Heavy Snow Rate Testing	-3	50	51.6	0	51.6	**23.1**	**23.8**
183	8-Mar-23	Dow EG106	IV	Aluminum	Heavy Snow	Heavy Snow Rate Testing	-3	50	51.6	0	51.6	**36.3**	**37.4**
184	8-Mar-23	Dow EG106	IV	Aluminum	Heavy Snow	Heavy Snow Rate Testing	-3	50	51.6	0	51.6	**37.0**	**38.1**
185	8-Mar-23	Dow PG ADF Concentrate	I	Aluminum	Heavy Snow	Heavy Snow Rate Testing	-3	100	100.3	0	100.3	**0.8**	**0.8**
187	8-Mar-23	Dow PG ADF Concentrate	I	Composite	Heavy Snow	Heavy Snow Rate Testing	-3	100	100.3	0	100.3	**0.5**	**0.5**
189	8-Mar-23	CHEMR REG I	I	Aluminum	Heavy Snow	Heavy Snow Rate Testing	-3	100	100.3	0	100.3	**1.3**	**1.3**
191	8-Mar-23	CHEMR REG I	I	Composite	Heavy Snow	Heavy Snow Rate Testing	-3	100	100.3	0	100.3	**0.9**	**0.9**
265	9-Mar-23	Dow PG ADF Concentrate	I	Aluminum	Heavy Snow and Freezing Fog	Heavy Snow Rate Testing	-3	52	-	-	52.3	**2.5**	**2.5**
267	9-Mar-23	Dow PG ADF Concentrate	I	Composite	Heavy Snow and Freezing Fog	Heavy Snow Rate Testing	-3	52	-	-	45.2	**1.6**	**1.4**
269	9-Mar-23	CHEMR REG I	I	Aluminum	Heavy Snow and Freezing Fog	Heavy Snow Rate Testing	-3	52	-	-	51.7	**2.6**	**2.6**
271	9-Mar-23	CHEMR REG I	I	Composite	Heavy Snow and Freezing Fog	Heavy Snow Rate Testing	-3	52	-	-	47.5	**1.5**	**1.3**
273	9-Mar-23	Clariant Safewing MP II FLIGHT	II	Aluminum	Heavy Snow and Freezing Fog	Heavy Snow Rate Testing	-3	52	-	-	52.3	**25.4**	**25.5**

Table 3.2: Test Log – Mixed Snow and Freezing Fog Endurance Time Testing at the NRC CEF (cont'd)

Test #	Date	Fluid Name	Fluid Type	Test Surface	Condition	Testing Sub-Objective	Temp. (°C)	Target Combined Rate (g/dm²/h)	Actual Rate (Snow Only)	Actual Rate (Freezing Fog Only)	Actual Rate (Combined)	Endurance Time (min)	Adjusted Endurance Time (min)
274	9-Mar-23	Clariant Safewing MP II FLIGHT	II	Aluminum	Heavy Snow and Freezing Fog	Heavy Snow Rate Testing	-3	52	-	-	51.7	**23.2**	**23.1**
275	9-Mar-23	AllClear AeroClear MAX	III	Aluminum	Heavy Snow and Freezing Fog	Heavy Snow Rate Testing	-3	52	-	-	45.2	**18.8**	**16.3**
276	9-Mar-23	AllClear AeroClear MAX	III	Aluminum	Heavy Snow and Freezing Fog	Heavy Snow Rate Testing	-3	52	-	-	47.5	**22.3**	**20.3**
277	9-Mar-23	Cryotech Polar Guard Advance	IV	Aluminum	Heavy Snow and Freezing Fog	Heavy Snow Rate Testing	-3	52	-	-	45.2	**35.6**	**30.9**
278	9-Mar-23	Cryotech Polar Guard Advance	IV	Aluminum	Heavy Snow and Freezing Fog	Heavy Snow Rate Testing	-3	52	-	-	47.5	**29.0**	**26.5**
279	9-Mar-23	Dow EG106	IV	Aluminum	Heavy Snow and Freezing Fog	Heavy Snow Rate Testing	-3	52	-	-	52.3	**39.7**	**39.9**
280	9-Mar-23	Dow EG106	IV	Aluminum	Heavy Snow and Freezing Fog	Heavy Snow Rate Testing	-3	52	-	-	51.7	**51.7**	**51.4**
281	9-Mar-23	Dow PG ADF Concentrate	I	Aluminum	Heavy Snow and Freezing Fog	Heavy Snow Rate Testing	-3	102	-	-	102.5	**1.5**	**1.5**
283	9-Mar-23	Dow PG ADF Concentrate	I	Composite	Heavy Snow and Freezing Fog	Heavy Snow Rate Testing	-3	102	-	-	100.1	**0.7**	**0.7**
285	9-Mar-23	CHEMR REG I	I	Aluminum	Heavy Snow and Freezing Fog	Heavy Snow Rate Testing	-3	102	-	-	111.1	**1.3**	**1.5**
287	9-Mar-23	CHEMR REG I	I	Composite	Heavy Snow and Freezing Fog	Heavy Snow Rate Testing	-3	102	-	-	93.6	**0.9**	**0.9**
289	9-Mar-23	Clariant Safewing MP II FLIGHT	II	Aluminum	Heavy Snow and Freezing Fog	Heavy Snow Rate Testing	-3	102	-	-	102.5	**8.4**	**8.4**
290	9-Mar-23	Clariant Safewing MP II FLIGHT	II	Aluminum	Heavy Snow and Freezing Fog	Heavy Snow Rate Testing	-3	102	-	-	111.1	**8.2**	**8.9**
291	9-Mar-23	AllClear AeroClear MAX	III	Aluminum	Heavy Snow and Freezing Fog	Heavy Snow Rate Testing	-3	102	-	-	100.1	**11.8**	**11.5**
292	9-Mar-23	AllClear AeroClear MAX	III	Aluminum	Heavy Snow and Freezing Fog	Heavy Snow Rate Testing	-3	102	-	-	93.6	**13.7**	**12.6**
293	9-Mar-23	Cryotech Polar Guard Advance	IV	Aluminum	Heavy Snow and Freezing Fog	Heavy Snow Rate Testing	-3	102	-	-	102.5	**14.8**	**14.9**
294	9-Mar-23	Cryotech Polar Guard Advance	IV	Aluminum	Heavy Snow and Freezing Fog	Heavy Snow Rate Testing	-3	102	-	-	111.1	**15.1**	**16.4**
295	9-Mar-23	Dow EG106	IV	Aluminum	Heavy Snow and Freezing Fog	Heavy Snow Rate Testing	-3	102	-	-	100.1	**21.7**	**21.3**

Table 3.2: Test Log – Mixed Snow and Freezing Fog Endurance Time Testing at the NRC CEF (cont'd)

Test #	Date	Fluid Name	Fluid Type	Test Surface	Condition	Testing Sub-Objective	Temp. (°C)	Target Combined Rate (g/dm²/h)	Actual Rate (Snow Only)	Actual Rate (Freezing Fog Only)	Actual Rate (Combined)	Endurance Time (min)	Adjusted Endurance Time (min)
296	9-Mar-23	Dow EG106	IV	Aluminum	Heavy Snow and Freezing Fog	Heavy Snow Rate Testing	-3	102	-	-	93.6	**23.9**	**21.9**
E1	8-Mar-23	Clariant Safewing MP II FLIGHT	II	Aluminum	Heavy Snow	Heavy Snow Rate Testing	-3	100	100.3	0	100.3	**7.6**	**7.7**
E2	8-Mar-23	Clariant Safewing MP II FLIGHT	II	Aluminum	Heavy Snow	Heavy Snow Rate Testing	-3	100	100.3	0	100.3	**8.2**	**8.2**
E3	8-Mar-23	AllClear AeroClear MAX	III	Aluminum	Heavy Snow	Heavy Snow Rate Testing	-3	100	100.3	0	100.3	**10.1**	**10.1**
E4	8-Mar-23	AllClear AeroClear MAX	III	Aluminum	Heavy Snow	Heavy Snow Rate Testing	-3	100	100.3	0	100.3	**11.4**	**11.4**
E5	8-Mar-23	Cryotech Polar Guard Advance	IV	Aluminum	Heavy Snow	Heavy Snow Rate Testing	-3	100	100.3	0	100.3	**10.3**	**10.3**
E6	8-Mar-23	Cryotech Polar Guard Advance	IV	Aluminum	Heavy Snow	Heavy Snow Rate Testing	-3	100	100.3	0	100.3	**12.0**	**12.0**
E7	8-Mar-23	Dow EG106	IV	Aluminum	Heavy Snow	Heavy Snow Rate Testing	-3	100	100.3	0	100.3	**18.4**	**18.4**
E8	8-Mar-23	Dow EG106	IV	Aluminum	Heavy Snow	Heavy Snow Rate Testing	-3	100	100.3	0	100.3	**20.2**	**20.3**
E9	9-Mar-23	AllClear AeroClear MAX	III	Aluminum	Heavy Snow and Freezing Fog	Heavy Snow Rate Testing	-3	52	-	-	52.3	**20.1**	**20.2**
E10	9-Mar-23	AllClear AeroClear MAX	III	Aluminum	Heavy Snow and Freezing Fog	Heavy Snow Rate Testing	-3	52	-	-	45.2	**21.8**	**18.9**
E11	9-Mar-23	AllClear AeroClear MAX	III	Aluminum	Heavy Snow and Freezing Fog	Heavy Snow Rate Testing	-3	52	-	-	47.5	**19.5**	**17.8**
E12	9-Mar-23	AllClear AeroClear MAX	III	Aluminum	Heavy Snow and Freezing Fog	Heavy Snow Rate Testing	-3	52	-	-	51.7	**19.7**	**19.6**
E13	9-Mar-23	Clariant Safewing MP II FLIGHT	II	Aluminum	Heavy Snow	Heavy Snow Rate Testing	-3	150	-	-	159.9	**6.5**	**6.9**
E14	9-Mar-23	Clariant Safewing MP II FLIGHT	II	Aluminum	Heavy Snow	Heavy Snow Rate Testing	-3	150	-	-	147.2	**5.6**	**5.5**
E15	9-Mar-23	AllClear AeroClear MAX	III	Aluminum	Heavy Snow	Heavy Snow Rate Testing	-3	150	-	-	160.4	**7.4**	**7.9**
E16	9-Mar-23	AllClear AeroClear MAX	III	Aluminum	Heavy Snow	Heavy Snow Rate Testing	-3	150	-	-	142.3	**8.3**	**7.9**
E17	9-Mar-23	Cryotech Polar Guard Advance	IV	Aluminum	Heavy Snow	Heavy Snow Rate Testing	-3	150	-	-	160.4	**6.2**	**6.6**

Table 3.2: Test Log – Mixed Snow and Freezing Fog Endurance Time Testing at the NRC CEF (cont'd)

Test #	Date	Fluid Name	Fluid Type	Test Surface	Condition	Testing Sub-Objective	Temp. (°C)	Target Combined Rate (g/dm²/h)	Actual Rate (Snow Only)	Actual Rate (Freezing Fog Only)	Actual Rate (Combined)	Endurance Time (min)	Adjusted Endurance Time (min)
E18	9-Mar-23	Cryotech Polar Guard Advance	IV	Aluminum	Heavy Snow	Heavy Snow Rate Testing	-3	150	-	-	142.3	**5.7**	**5.4**
E19	9-Mar-23	Dow EG106	IV	Aluminum	Heavy Snow	Heavy Snow Rate Testing	-3	150	-	-	159.9	**10.2**	**10.9**
E20	9-Mar-23	Dow EG106	IV	Aluminum	Heavy Snow	Heavy Snow Rate Testing	-3	150	-	-	147.2	**10.4**	**10.2**
E29	17-Mar-23	Clariant Safewing MP II FLIGHT	II	Aluminum	Moderate Snow	New Snow Baseline Testing	-3	10	10.1	0	10.1	**93.9**	**94.8**
E30	17-Mar-23	Clariant Safewing MP II FLIGHT	II	Aluminum	Moderate Snow	New Snow Baseline Testing	-3	10	10.1	0	10.1	**108.4**	**109.4**
E31	17-Mar-23	AllClear AeroClear MAX	III	Aluminum	Moderate Snow	New Snow Baseline Testing	-3	10	10.1	0	10.1	**43.1**	**43.6**
E32	17-Mar-23	AllClear AeroClear MAX	III	Aluminum	Moderate Snow	New Snow Baseline Testing	-3	10	10.1	0	10.1	**41.7**	**42.1**
E33	17-Mar-23	Cryotech Polar Guard Advance	IV	Aluminum	Moderate Snow	New Snow Baseline Testing	-3	10	10.1	0	10.1	**142.4**	**143.8**
E34	17-Mar-23	Cryotech Polar Guard Advance	IV	Aluminum	Moderate Snow	New Snow Baseline Testing	-3	10	10.1	0	10.1	**116.9**	**118.1**
E35	17-Mar-23	Dow EG106	IV	Aluminum	Moderate Snow	New Snow Baseline Testing	-3	10	10.1	0	10.1	**95.5**	**96.5**
E36	17-Mar-23	Dow EG106	IV	Aluminum	Moderate Snow	New Snow Baseline Testing	-3	10	10.1	0	10.1	**83.2**	**84.0**
E37	15-Mar-23	Clariant Safewing MP II FLIGHT	II	Aluminum	Moderate Snow	New Snow Baseline Testing	-3	25	28.1	0	28.1	**29.4**	**33.1**
E38	15-Mar-23	Clariant Safewing MP II FLIGHT	II	Aluminum	Moderate Snow	New Snow Baseline Testing	-3	25	28.1	0	28.1	**33.1**	**37.2**
E39	15-Mar-23	AllClear AeroClear MAX	III	Aluminum	Moderate Snow	New Snow Baseline Testing	-3	25	28.1	0	28.1	**28.8**	**32.4**
E40	15-Mar-23	AllClear AeroClear MAX	III	Aluminum	Moderate Snow	New Snow Baseline Testing	-3	25	28.1	0	28.1	**22.7**	**25.5**
E41	15-Mar-23	Cryotech Polar Guard Advance	IV	Aluminum	Moderate Snow	New Snow Baseline Testing	-3	25	28.1	0	28.1	**32.3**	**36.3**
E42	15-Mar-23	Cryotech Polar Guard Advance	IV	Aluminum	Moderate Snow	New Snow Baseline Testing	-3	25	28.1	0	28.1	**35.0**	**39.3**
E43	15-Mar-23	Dow EG106	IV	Aluminum	Moderate Snow	New Snow Baseline Testing	-3	25	28.1	0	28.1	**51.2**	**57.6**

Table 3.2: Test Log – Mixed Snow and Freezing Fog Endurance Time Testing at the NRC CEF (cont'd)

Test #	Date	Fluid Name	Fluid Type	Test Surface	Condition	Testing Sub-Objective	Temp. (°C)	Target Combined Rate (g/dm²/h)	Actual Rate (Snow Only)	Actual Rate (Freezing Fog Only)	Actual Rate (Combined)	Endurance Time (min)	Adjusted Endurance Time (min)
E44	15-Mar-23	Dow EG106	IV	Aluminum	Moderate Snow	New Snow Baseline Testing	-3	25	28.1	0	28.1	**47.7**	**53.6**
E45	15-Mar-23	Clariant Safewing MP II FLIGHT	II	Aluminum	Moderate Snow	New Snow Baseline Testing	-14	10	9.9	0	9.9	**52.1**	**51.5**
E46	15-Mar-23	Clariant Safewing MP II FLIGHT	II	Aluminum	Moderate Snow	New Snow Baseline Testing	-14	10	9.9	0	9.9	**50.5**	**50.0**
E47	15-Mar-23	AllClear AeroClear MAX	III	Aluminum	Moderate Snow	New Snow Baseline Testing	-14	10	9.9	0	9.9	**89.3**	**88.4**
E48	15-Mar-23	AllClear AeroClear MAX	III	Aluminum	Moderate Snow	New Snow Baseline Testing	-14	10	9.9	0	9.9	**82.1**	**81.3**
E49	15-Mar-23	Cryotech Polar Guard Advance	IV	Aluminum	Moderate Snow	New Snow Baseline Testing	-14	10	9.9	0	9.9	**63.4**	**62.8**
E50	15-Mar-23	Cryotech Polar Guard Advance	IV	Aluminum	Moderate Snow	New Snow Baseline Testing	-14	10	9.9	0	9.9	**63.4**	**62.8**
E51	15-Mar-23	Dow EG106	IV	Aluminum	Moderate Snow	New Snow Baseline Testing	-14	10	9.9	0	9.9	**103.6**	**102.6**
E52	15-Mar-23	Dow EG106	IV	Aluminum	Moderate Snow	New Snow Baseline Testing	-14	10	9.9	0	9.9	**91.2**	**90.3**
E53	14-Mar-23	Clariant Safewing MP II FLIGHT	II	Aluminum	Moderate Snow	New Snow Baseline Testing	-14	25	24.9	0	24.9	**26.9**	**26.8**
E54	14-Mar-23	Clariant Safewing MP II FLIGHT	II	Aluminum	Moderate Snow	New Snow Baseline Testing	-14	25	24.9	0	24.9	**29.0**	**28.9**
E55	14-Mar-23	AllClear AeroClear MAX	III	Aluminum	Moderate Snow	New Snow Baseline Testing	-14	25	24.9	0	24.9	**45.1**	**45.0**
E56	14-Mar-23	AllClear AeroClear MAX	III	Aluminum	Moderate Snow	New Snow Baseline Testing	-14	25	24.9	0	24.9	**45.1**	**44.9**
E57	14-Mar-23	Cryotech Polar Guard Advance	IV	Aluminum	Moderate Snow	New Snow Baseline Testing	-14	25	24.9	0	24.9	**32.5**	**32.4**
E58	14-Mar-23	Cryotech Polar Guard Advance	IV	Aluminum	Moderate Snow	New Snow Baseline Testing	-14	25	24.9	0	24.9	**28.7**	**28.6**
E59	14-Mar-23	Dow EG106	IV	Aluminum	Moderate Snow	New Snow Baseline Testing	-14	25	24.9	0	24.9	**54.7**	**54.4**
E60	14-Mar-23	Dow EG106	IV	Aluminum	Moderate Snow	New Snow Baseline Testing	-14	25	24.9	0	24.9	**54.8**	**54.5**
E61	13-Mar-23	Clariant Safewing MP II FLIGHT	II	Aluminum	Moderate Snow	New Snow Baseline Testing	-25	10	10.3	0	10.3	**32.5**	**33.4**

Table 3.2: Test Log – Mixed Snow and Freezing Fog Endurance Time Testing at the NRC CEF (cont'd)

Test #	Date	Fluid Name	Fluid Type	Test Surface	Condition	Testing Sub-Objective	Temp. (°C)	Target Combined Rate (g/dm²/h)	Actual Rate (Snow Only)	Actual Rate (Freezing Fog Only)	Actual Rate (Combined)	Endurance Time (min)	Adjusted Endurance Time (min)
E62	13-Mar-23	Clariant Safewing MP II FLIGHT	II	Aluminum	Moderate Snow	New Snow Baseline Testing	-25	10	10.3	0	10.3	**31.4**	**32.3**
E63	13-Mar-23	AllClear AeroClear MAX	III	Aluminum	Moderate Snow	New Snow Baseline Testing	-25	10	10.3	0	10.3	**84.3**	**86.8**
E64	13-Mar-23	AllClear AeroClear MAX	III	Aluminum	Moderate Snow	New Snow Baseline Testing	-25	10	10.3	0	10.3	**77.7**	**80.1**
E65	13-Mar-23	Cryotech Polar Guard Advance	IV	Aluminum	Moderate Snow	New Snow Baseline Testing	-25	10	10.3	0	10.3	**36.1**	**37.2**
E66	13-Mar-23	Cryotech Polar Guard Advance	IV	Aluminum	Moderate Snow	New Snow Baseline Testing	-25	10	10.3	0	10.3	**35.4**	**36.4**
E67	13-Mar-23	Dow EG106	IV	Aluminum	Moderate Snow	New Snow Baseline Testing	-25	10	10.3	0	10.3	**79.0**	**81.3**
E68	13-Mar-23	Dow EG106	IV	Aluminum	Moderate Snow	New Snow Baseline Testing	-25	10	10.3	0	10.3	**81.9**	**84.3**
E69	13-Mar-23	Clariant Safewing MP II FLIGHT	II	Aluminum	Moderate Snow	New Snow Baseline Testing	-25	25	26.1	0	26.1	**16.1**	**16.8**
E70	13-Mar-23	Clariant Safewing MP II FLIGHT	II	Aluminum	Moderate Snow	New Snow Baseline Testing	-25	25	26.1	0	26.1	**15.3**	**16.0**
E71	13-Mar-23	AllClear AeroClear MAX	III	Aluminum	Moderate Snow	New Snow Baseline Testing	-25	25	26.1	0	26.1	**28.4**	**29.7**
E72	13-Mar-23	AllClear AeroClear MAX	III	Aluminum	Moderate Snow	New Snow Baseline Testing	-25	25	26.1	0	26.1	**30.4**	**31.7**
E73	13-Mar-23	Cryotech Polar Guard Advance	IV	Aluminum	Moderate Snow	New Snow Baseline Testing	-25	25	26.1	0	26.1	**16.9**	**17.7**
E74	13-Mar-23	Cryotech Polar Guard Advance	IV	Aluminum	Moderate Snow	New Snow Baseline Testing	-25	25	26.1	0	26.1	**17.5**	**18.2**
E75	13-Mar-23	Dow EG106	IV	Aluminum	Moderate Snow	New Snow Baseline Testing	-25	25	26.1	0	26.1	**26.8**	**27.9**
E76	13-Mar-23	Dow EG106	IV	Aluminum	Moderate Snow	New Snow Baseline Testing	-25	25	26.1	0	26.1	**32.3**	**33.7**

Table 3.3: Test Log – Mixed Snow and Rain Endurance Time Testing at the NRC CEF

Test #	Date	Fluid Name	Fluid Type	Test Surface	Condition	Temp. (°C)	Target Combined Rate (g/dm²/h)	Actual Rate (Snow Only)	Actual Rate (Rain/Freezing Rain Only)	Actual Rate (Combined)	Endurance Time (min)	Adjusted Endurance Time (min)
1	28-Feb-23	Dow PG ADF Concentrate	I	Aluminum	Moderate Rain mixed with Snow	-3	25	0	24.6	24.6	23.9	23.6
2	28-Feb-23	Dow PG ADF Concentrate	I	Aluminum	Moderate Rain mixed with Snow	-3	25	0	24.6	24.6	19.6	19.3
3	28-Feb-23	Dow PG ADF Concentrate	I	Composite	Moderate Rain mixed with Snow	-3	25	0	24.9	24.9	23.4	23.3
4	28-Feb-23	Dow PG ADF Concentrate	I	Composite	Moderate Rain mixed with Snow	-3	25	0	24.9	24.9	21.1	21.0
5	28-Feb-23	CHEMR REG I	I	Aluminum	Moderate Rain mixed with Snow	-3	25	0	25.1	25.1	19.5	19.6
6	28-Feb-23	CHEMR REG I	I	Aluminum	Moderate Rain mixed with Snow	-3	25	0	25.1	25.1	17.0	17.0
7	28-Feb-23	CHEMR REG I	I	Composite	Moderate Rain mixed with Snow	-3	25	0	24.6	24.6	13.6	13.4
8	28-Feb-23	CHEMR REG I	I	Composite	Moderate Rain mixed with Snow	-3	25	0	24.6	24.6	14.7	14.5
9	28-Feb-23	Clariant Safewing MP II FLIGHT	II	Aluminum	Moderate Rain mixed with Snow	-3	25	0	24.7	24.7	43.0	42.5
10	28-Feb-23	Clariant Safewing MP II FLIGHT	II	Aluminum	Moderate Rain mixed with Snow	-3	25	0	25.3	25.3	43.3	43.8
11	28-Feb-23	AllClear AeroClear MAX	III	Aluminum	Moderate Rain mixed with Snow	-3	25	0	24.7	24.7	17.5	17.3
12	28-Feb-23	AllClear AeroClear MAX	III	Aluminum	Moderate Rain mixed with Snow	-3	25	0	25	25	18.0	18.0
13	28-Feb-23	Cryotech Polar Guard Advance	IV	Aluminum	Moderate Rain mixed with Snow	-3	25	0	25.5	25.5	48.9	49.9
14	28-Feb-23	Cryotech Polar Guard Advance	IV	Aluminum	Moderate Rain mixed with Snow	-3	25	0	25.5	25.5	49.2	50.2
15	28-Feb-23	Dow EG106	IV	Aluminum	Moderate Rain mixed with Snow	-3	25	0	25.5	25.5	50.9	51.9
16	28-Feb-23	Dow EG106	IV	Aluminum	Moderate Rain mixed with Snow	-3	25	0	25.1	25.1	52.4	52.6
17	1-Mar-23	Dow PG ADF Concentrate	I	Aluminum	Moderate Rain mixed with Snow	0	75	22.4	54.3	76.7	6.5	6.6
18	1-Mar-23	Dow PG ADF Concentrate	I	Aluminum	Moderate Rain mixed with Snow	0	75	22.4	54.3	76.7	6.6	6.7
19	1-Mar-23	Dow PG ADF Concentrate	I	Composite	Moderate Rain mixed with Snow	0	75	25.1	52.6	77.7	4.8	5.0
20	1-Mar-23	Dow PG ADF Concentrate	I	Composite	Moderate Rain mixed with Snow	0	75	25.1	52.6	77.7	5.9	6.2
21	1-Mar-23	CHEMR REG I	I	Aluminum	Moderate Rain mixed with Snow	0	75	22.2	50.7	72.9	6.5	6.3

Table 3.3: Test Log – Mixed Snow and Rain Endurance Time Testing at the NRC CEF (cont'd)

Test #	Date	Fluid Name	Fluid Type	Test Surface	Condition	Temp. (°C)	Target Combined Rate (g/dm²/h)	Actual Rate (Snow Only)	Actual Rate (Rain/Freezing Rain Only)	Actual Rate (Combined)	Endurance Time (min)	Adjusted Endurance Time (min)
22	1-Mar-23	CHEMR REG I	I	Aluminum	Moderate Rain mixed with Snow	0	75	22.2	50.7	72.9	6.4	6.2
23	1-Mar-23	CHEMR REG I	I	Composite	Moderate Rain mixed with Snow	0	75	23.5	49.9	73.4	4.9	4.8
24	1-Mar-23	CHEMR REG I	I	Composite	Moderate Rain mixed with Snow	0	75	23.5	49.9	73.4	5.8	5.7
25	1-Mar-23	Clariant Safewing MP II FLIGHT	II	Aluminum	Moderate Rain mixed with Snow	0	75	24.9	51.2	76.1	16.0	16.3
26	1-Mar-23	Clariant Safewing MP II FLIGHT	II	Aluminum	Moderate Rain mixed with Snow	0	75	24.9	51.2	76.1	13.9	14.1
27	1-Mar-23	AllClear AeroClear MAX	III	Aluminum	Moderate Rain mixed with Snow	0	75	24.9	51.2	76.1	9.4	9.5
28	1-Mar-23	AllClear AeroClear MAX	III	Aluminum	Moderate Rain mixed with Snow	0	75	24.9	51.2	76.1	10.0	10.2
29	1-Mar-23	Cryotech Polar Guard Advance	IV	Aluminum	Moderate Rain mixed with Snow	0	75	24.9	51.2	76.1	17.9	18.1
30	1-Mar-23	Cryotech Polar Guard Advance	IV	Aluminum	Moderate Rain mixed with Snow	0	75	24.9	51.2	76.1	18.7	19.0
31	1-Mar-23	Dow EG106	IV	Aluminum	Moderate Rain mixed with Snow	0	75	24.9	51.2	76.1	15.8	16.0
32	1-Mar-23	Dow EG106	IV	Aluminum	Moderate Rain mixed with Snow	0	75	24.9	51.2	76.1	15.8	16.0
33	3-Mar-23	Dow PG ADF Concentrate	I	Aluminum	Moderate Rain mixed with Snow	0	75	10.1	67.1	77.2	10.0	10.3
35	3-Mar-23	Dow PG ADF Concentrate	I	Composite	Moderate Rain mixed with Snow	0	75	10.5	67.3	77.8	3.4	3.5
37	3-Mar-23	CHEMR REG I	I	Aluminum	Moderate Rain mixed with Snow	0	75	10.7	64.7	75.4	9.0	9.1
39	3-Mar-23	CHEMR REG I	I	Composite	Moderate Rain mixed with Snow	0	75	10	65.4	75.4	3.1	3.1
41	3-Mar-23	Clariant Safewing MP II FLIGHT	II	Aluminum	Moderate Rain mixed with Snow	0	75	8.2	64.3	72.5	16.4	15.8
42	3-Mar-23	Clariant Safewing MP II FLIGHT	II	Aluminum	Moderate Rain mixed with Snow	0	75	8.2	64.3	72.5	15.4	14.9
43	3-Mar-23	AllClear AeroClear MAX	III	Aluminum	Moderate Rain mixed with Snow	0	75	8.2	64.3	72.5	11.1	10.7
44	3-Mar-23	AllClear AeroClear MAX	III	Aluminum	Moderate Rain mixed with Snow	0	75	8.2	64.3	72.5	11.2	10.8
45	3-Mar-23	Cryotech Polar Guard Advance	IV	Aluminum	Moderate Rain mixed with Snow	0	75	8.2	64.3	72.5	17.1	16.5
46	3-Mar-23	Cryotech Polar Guard Advance	IV	Aluminum	Moderate Rain mixed with Snow	0	75	8.2	64.3	72.5	14.9	14.4
47	3-Mar-23	Dow EG106	IV	Aluminum	Moderate Rain mixed with Snow	0	75	8.2	64.3	72.5	15.4	14.9

Table 3.3: Test Log – Mixed Snow and Rain Endurance Time Testing at the NRC CEF (cont'd)

Test #	Date	Fluid Name	Fluid Type	Test Surface	Condition	Temp. (°C)	Target Combined Rate (g/dm²/h)	Actual Rate (Snow Only)	Actual Rate (Rain/Freezing Rain Only)	Actual Rate (Combined)	Endurance Time (min)	Adjusted Endurance Time (min)
48	3-Mar-23	Dow EG106	IV	Aluminum	Moderate Rain mixed with Snow	0	75	8.2	64.3	72.5	13.8	13.4
49	15-Mar-23	Dow PG ADF Concentrate	I	Aluminum	Moderate Snow mixed with Rain	-3	10	10.3	0	10.3	5.5	5.6
51	15-Mar-23	Dow PG ADF Concentrate	I	Composite	Moderate Snow mixed with Rain	-3	10	10	0	10	3.8	3.8
53	15-Mar-23	CHEMR REG I	I	Aluminum	Moderate Snow mixed with Rain	-3	10	9.3	0	9.3	6.4	6.0
55	15-Mar-23	CHEMR REG I	I	Composite	Moderate Snow mixed with Rain	-3	10	9.9	0	9.9	4.3	4.3
57	17-Mar-23	Clariant Safewing MP II FLIGHT	II	Aluminum	Moderate Snow mixed with Rain	-3	10	10.1	0	10.1	93.9	94.8
58	17-Mar-23	Clariant Safewing MP II FLIGHT	II	Aluminum	Moderate Snow mixed with Rain	-3	10	10.1	0	10.1	108.4	109.4
59	17-Mar-23	AllClear AeroClear MAX	III	Aluminum	Moderate Snow mixed with Rain	-3	10	10.1	0	10.1	43.1	43.6
60	17-Mar-23	AllClear AeroClear MAX	III	Aluminum	Moderate Snow mixed with Rain	-3	10	10.1	0	10.1	41.7	42.1
61	17-Mar-23	Cryotech Polar Guard Advance	IV	Aluminum	Moderate Snow mixed with Rain	-3	10	10.1	0	10.1	142.4	143.8
62	17-Mar-23	Cryotech Polar Guard Advance	IV	Aluminum	Moderate Snow mixed with Rain	-3	10	10.1	0	10.1	116.9	118.1
63	17-Mar-23	Dow EG106	IV	Aluminum	Moderate Snow mixed with Rain	-3	10	10.1	0	10.1	95.5	96.5
64	17-Mar-23	Dow EG106	IV	Aluminum	Moderate Snow mixed with Rain	-3	10	10.1	0	10.1	83.2	84.0
65	15-Mar-23	Dow PG ADF Concentrate	I	Aluminum	Moderate Snow mixed with Rain	-3	25	30.6	0	30.6	4.1	5.0
67	15-Mar-23	Dow PG ADF Concentrate	I	Composite	Moderate Snow mixed with Rain	-3	25	26.4	0	26.4	2.2	2.3
69	15-Mar-23	CHEMR REG I	I	Aluminum	Moderate Snow mixed with Rain	-3	25	26.7	0	26.7	4.2	4.5
71	15-Mar-23	CHEMR REG I	I	Composite	Moderate Snow mixed with Rain	-3	25	23.8	0	23.8	2.3	2.2
73	15-Mar-23	Clariant Safewing MP II FLIGHT	II	Aluminum	Moderate Snow mixed with Rain	-3	25	28.1	0	28.1	29.4	33.1
74	15-Mar-23	Clariant Safewing MP II FLIGHT	II	Aluminum	Moderate Snow mixed with Rain	-3	25	28.1	0	28.1	33.1	37.2
75	15-Mar-23	AllClear AeroClear MAX	III	Aluminum	Moderate Snow mixed with Rain	-3	25	28.1	0	28.1	28.8	32.4
76	15-Mar-23	AllClear AeroClear MAX	III	Aluminum	Moderate Snow mixed with Rain	-3	25	28.1	0	28.1	22.7	25.5
77	15-Mar-23	Cryotech Polar Guard Advance	IV	Aluminum	Moderate Snow mixed with Rain	-3	25	28.1	0	28.1	32.3	36.3

Table 3.3: Test Log – Mixed Snow and Rain Endurance Time Testing at the NRC CEF (cont'd)

Test #	Date	Fluid Name	Fluid Type	Test Surface	Condition	Temp. (°C)	Target Combined Rate (g/dm²/h)	Actual Rate (Snow Only)	Actual Rate (Rain/Freezing Rain Only)	Actual Rate (Combined)	Endurance Time (min)	Adjusted Endurance Time (min)
78	15-Mar-23	Cryotech Polar Guard Advance	IV	Aluminum	Moderate Snow mixed with Rain	-3	25	28.1	0	28.1	35.0	39.3
79	15-Mar-23	Dow EG106	IV	Aluminum	Moderate Snow mixed with Rain	-3	25	28.1	0	28.1	51.2	57.6
80	15-Mar-23	Dow EG106	IV	Aluminum	Moderate Snow mixed with Rain	-3	25	28.1	0	28.1	47.7	53.6
R1	28-Feb-23	Dow PG ADF Concentrate	I	Aluminum	Moderate Snow mixed with Rain	-3	25	0	24.6	24.6	23.9	23.6
R2	28-Feb-23	Dow PG ADF Concentrate	I	Aluminum	Moderate Snow mixed with Rain	-3	25	0	24.6	24.6	19.6	19.3
R3	28-Feb-23	Dow PG ADF Concentrate	I	Composite	Moderate Snow mixed with Rain	-3	25	0	24.9	24.9	23.4	23.3
R4	28-Feb-23	Dow PG ADF Concentrate	I	Composite	Moderate Snow mixed with Rain	-3	25	0	24.9	24.9	21.1	21.0
R5	28-Feb-23	CHEMR REG I	I	Aluminum	Moderate Snow mixed with Rain	-3	25	0	25.1	25.1	19.5	19.6
R6	28-Feb-23	CHEMR REG I	I	Aluminum	Moderate Snow mixed with Rain	-3	25	0	25.1	25.1	17.0	17.0
R7	28-Feb-23	CHEMR REG I	I	Composite	Moderate Snow mixed with Rain	-3	25	0	24.6	24.6	13.6	13.4
R8	28-Feb-23	CHEMR REG I	I	Composite	Moderate Snow mixed with Rain	-3	25	0	24.6	24.6	14.7	14.5
R9	28-Feb-23	Clariant Safewing MP II FLIGHT	II	Aluminum	Moderate Snow mixed with Rain	-3	25	0	24.7	24.7	43.0	42.5
R10	28-Feb-23	Clariant Safewing MP II FLIGHT	II	Aluminum	Moderate Snow mixed with Rain	-3	25	0	25.3	25.3	43.3	43.8
R11	28-Feb-23	AllClear AeroClear MAX	III	Aluminum	Moderate Snow mixed with Rain	-3	25	0	24.7	24.7	17.5	17.3
R12	28-Feb-23	AllClear AeroClear MAX	III	Aluminum	Moderate Snow mixed with Rain	-3	25	0	25	25	18.0	18.0
R13	28-Feb-23	Cryotech Polar Guard Advance	IV	Aluminum	Moderate Snow mixed with Rain	-3	25	0	25.5	25.5	48.9	49.9
R14	28-Feb-23	Cryotech Polar Guard Advance	IV	Aluminum	Moderate Snow mixed with Rain	-3	25	0	25.5	25.5	49.2	50.2
R15	28-Feb-23	Dow EG106	IV	Aluminum	Moderate Snow mixed with Rain	-3	25	0	25.5	25.5	50.9	51.9
R16	28-Feb-23	Dow EG106	IV	Aluminum	Moderate Snow mixed with Rain	-3	25	0	25.1	25.1	52.4	52.6
225	7-Mar-23	Dow PG ADF Concentrate	I	Aluminum	Moderate Snow mixed with Rain	0	35	26.6	12.8	39.4	4.0	4.5
227	7-Mar-23	Dow PG ADF Concentrate	I	Composite	Moderate Snow mixed with Rain	0	35	24.6	12	36.6	2.0	2.1
229	7-Mar-23	CHEMR REG I	I	Aluminum	Moderate Snow mixed with Rain	0	35	27.3	12.2	39.5	4.0	4.5

Table 3.3: Test Log – Mixed Snow and Rain Endurance Time Testing at the NRC CEF (cont'd)

Test #	Date	Fluid Name	Fluid Type	Test Surface	Condition	Temp. (°C)	Target Combined Rate (g/dm²/h)	Actual Rate (Snow Only)	Actual Rate (Rain/Freezing Rain Only)	Actual Rate (Combined)	Endurance Time (min)	Adjusted Endurance Time (min)
231	7-Mar-23	CHEMR REG I	I	Composite	Moderate Snow mixed with Rain	0	35	25.7	12.4	38.1	2.2	2.4
233	7-Mar-23	Clariant Safewing MP II FLIGHT	II	Aluminum	Moderate Snow mixed with Rain	0	35	25.4	12.2	37.6	33.1	35.6
234	7-Mar-23	Clariant Safewing MP II FLIGHT	II	Aluminum	Moderate Snow mixed with Rain	0	35	25.4	12.2	37.6	34.9	37.5
235	7-Mar-23	AllClear AeroClear MAX	III	Aluminum	Moderate Snow mixed with Rain	0	35	25.4	12.2	37.6	13.4	14.4
236	7-Mar-23	AllClear AeroClear MAX	III	Aluminum	Moderate Snow mixed with Rain	0	35	25.4	12.2	37.6	15.7	16.8
237	7-Mar-23	Cryotech Polar Guard Advance	IV	Aluminum	Moderate Snow mixed with Rain	0	35	25.4	12.2	37.6	35.2	37.9
238	7-Mar-23	Cryotech Polar Guard Advance	IV	Aluminum	Moderate Snow mixed with Rain	0	35	25.4	12.2	37.6	31.6	34.0
239	7-Mar-23	Dow EG106	IV	Aluminum	Moderate Snow mixed with Rain	0	35	25.4	12.2	37.6	40.6	43.6
240	7-Mar-23	Dow EG106	IV	Aluminum	Moderate Snow mixed with Rain	0	35	25.4	12.2	37.6	42.3	45.4
241	2-Mar-23	Dow PG ADF Concentrate	I	Aluminum	Moderate Snow mixed with Rain	0	50	23.5	25.3	48.8	5.5	5.4
243	2-Mar-23	Dow PG ADF Concentrate	I	Composite	Moderate Snow mixed with Rain	0	50	28.6	25	53.6	2.2	2.4
245	2-Mar-23	CHEMR REG I	I	Aluminum	Moderate Snow mixed with Rain	0	50	25.8	25.5	51.3	4.5	4.6
247	2-Mar-23	CHEMR REG I	I	Composite	Moderate Snow mixed with Rain	0	50	22.3	25.6	47.9	2.4	2.3
249	2-Mar-23	Clariant Safewing MP II FLIGHT	II	Aluminum	Moderate Snow mixed with Rain	0	50	23.9	24.7	48.6	25.5	24.8
250	2-Mar-23	Clariant Safewing MP II FLIGHT	II	Aluminum	Moderate Snow mixed with Rain	0	50	23.9	24.7	48.6	27.6	26.8
251	2-Mar-23	AllClear AeroClear MAX	III	Aluminum	Moderate Snow mixed with Rain	0	50	23.9	24.7	48.6	13.4	13.0
252	2-Mar-23	AllClear AeroClear MAX	III	Aluminum	Moderate Snow mixed with Rain	0	50	23.9	24.7	48.6	11.7	11.4
253	2-Mar-23	Cryotech Polar Guard Advance	IV-PG	Aluminum	Moderate Snow mixed with Rain	0	50	23.9	24.7	48.6	30.8	29.9
254	2-Mar-23	Cryotech Polar Guard Advance	IV-PG	Aluminum	Moderate Snow mixed with Rain	0	50	23.9	24.7	48.6	30.2	29.4
255	2-Mar-23	Dow EG106	IV-EG	Aluminum	Moderate Snow mixed with Rain	0	50	23.9	24.7	48.6	39.7	38.5
256	2-Mar-23	Dow EG106	IV-EG	Aluminum	Moderate Snow mixed with Rain	0	50	23.9	24.7	48.6	33.4	32.5
R17	1-Mar-23	Dow PG ADF Concentrate	I	Aluminum	Moderate Snow mixed with Rain	0	75	22.4	54.3	76.7	6.5	6.6

Table 3.3: Test Log – Mixed Snow and Rain Endurance Time Testing at the NRC CEF (cont'd)

Test #	Date	Fluid Name	Fluid Type	Test Surface	Condition	Temp. (°C)	Target Combined Rate (g/dm²/h)	Actual Rate (Snow Only)	Actual Rate (Rain/Freezing Rain Only)	Actual Rate (Combined)	Endurance Time (min)	Adjusted Endurance Time (min)
R18	1-Mar-23	Dow PG ADF Concentrate	I	Aluminum	Moderate Snow mixed with Rain	0	75	22.4	54.3	76.7	6.6	6.7
R19	1-Mar-23	Dow PG ADF Concentrate	I	Composite	Moderate Snow mixed with Rain	0	75	25.1	52.6	77.7	4.8	5.0
R20	1-Mar-23	Dow PG ADF Concentrate	I	Composite	Moderate Snow mixed with Rain	0	75	25.1	52.6	77.7	5.9	6.2
R21	1-Mar-23	CHEMR REG I	I	Aluminum	Moderate Snow mixed with Rain	0	75	22.2	50.7	72.9	6.5	6.3
R22	1-Mar-23	CHEMR REG I	I	Aluminum	Moderate Snow mixed with Rain	0	75	22.2	50.7	72.9	6.4	6.2
R23	1-Mar-23	CHEMR REG I	I	Composite	Moderate Snow mixed with Rain	0	75	23.5	49.9	73.4	4.9	4.8
R24	1-Mar-23	CHEMR REG I	I	Composite	Moderate Snow mixed with Rain	0	75	23.5	49.9	73.4	5.8	5.7
R25	1-Mar-23	Clariant Safewing MP II FLIGHT	II	Aluminum	Moderate Snow mixed with Rain	0	75	24.9	51.2	76.1	16.0	16.3
R26	1-Mar-23	Clariant Safewing MP II FLIGHT	II	Aluminum	Moderate Snow mixed with Rain	0	75	24.9	51.2	76.1	13.9	14.1
R27	1-Mar-23	AllClear AeroClear MAX	III	Aluminum	Moderate Snow mixed with Rain	0	75	24.9	51.2	76.1	9.4	9.5
R28	1-Mar-23	AllClear AeroClear MAX	III	Aluminum	Moderate Snow mixed with Rain	0	75	24.9	51.2	76.1	10.0	10.2
R29	1-Mar-23	Cryotech Polar Guard Advance	IV-PG	Aluminum	Moderate Snow mixed with Rain	0	75	24.9	51.2	76.1	17.9	18.1
R30	1-Mar-23	Cryotech Polar Guard Advance	IV-PG	Aluminum	Moderate Snow mixed with Rain	0	75	24.9	51.2	76.1	18.7	19.0
R31	1-Mar-23	Dow EG106	IV-EG	Aluminum	Moderate Snow mixed with Rain	0	75	24.9	51.2	76.1	15.8	16.0
R32	1-Mar-23	Dow EG106	IV-EG	Aluminum	Moderate Snow mixed with Rain	0	75	24.9	51.2	76.1	15.8	16.0
E5	6-Mar-23	Dow PG ADF Concentrate	I	Aluminum	Moderate Snow mixed with Rain	0	75	4.5	71.5	76	27.6	28.0
E6	6-Mar-23	Dow PG ADF Concentrate	I	Composite	Moderate Snow mixed with Rain	0	75	5.2	71.8	77	39.2	40.2
E7	6-Mar-23	CHEMR REG I	I	Aluminum	Moderate Snow mixed with Rain	0	75	2.7	72.6	75.3	27.7	27.8
E8	6-Mar-23	CHEMR REG I	I	Composite	Moderate Snow mixed with Rain	0	75	4.6	70.4	75	39.2	39.2
E9	3-Mar-23	Clariant Safewing MP II FLIGHT	II	Aluminum	Moderate Snow mixed with Rain	0	75	-	-	72.5	21.5	20.8
E10	3-Mar-23	Clariant Safewing MP II FLIGHT	II	Aluminum	Moderate Snow mixed with Rain	0	75	-	-	72.5	20.6	20.0
E11	3-Mar-23	AllClear AeroClear MAX	III	Aluminum	Moderate Snow mixed with Rain	0	75	-	-	72.5	12.2	11.8

Table 3.3: Test Log – Mixed Snow and Rain Endurance Time Testing at the NRC CEF (cont'd)

Test #	Date	Fluid Name	Fluid Type	Test Surface	Condition	Temp. (°C)	Target Combined Rate (g/dm²/h)	Actual Rate (Snow Only)	Actual Rate (Rain/Freezing Rain Only)	Actual Rate (Combined)	Endurance Time (min)	Adjusted Endurance Time (min)
E12	3-Mar-23	AllClear AeroClear MAX	III	Aluminum	Moderate Snow mixed with Rain	0	75	-	-	72.5	11.9	11.5
E13	3-Mar-23	Cryotech Polar Guard Advance	IV-PG	Aluminum	Moderate Snow mixed with Rain	0	75	-	-	72.5	21.1	20.4
E14	3-Mar-23	Cryotech Polar Guard Advance	IV-PG	Aluminum	Moderate Snow mixed with Rain	0	75	-	-	72.5	28.6	27.7
E15	3-Mar-23	Dow EG106	IV-EG	Aluminum	Moderate Snow mixed with Rain	0	75	-	-	72.5	20.0	19.3
E16	3-Mar-23	Dow EG106	IV-EG	Aluminum	Moderate Snow mixed with Rain	0	75	-	-	72.5	20.6	19.9
E17	28-Mar-23	Dow PG ADF Concentrate	I-PG	Aluminum	Moderate Snow mixed with Rain	1	75	-	-	75.4	1.9	1.9
E18	28-Mar-23	Dow PG ADF Concentrate	I-PG	Composite	Moderate Snow mixed with Rain	1	75	-	-	76.1	2.4	2.4
E19	28-Mar-23	CHEMR REG I	I-EG	Aluminum	Moderate Snow mixed with Rain	1	75	-	-	75.4	2.0	2.0
E20	28-Mar-23	CHEMR REG I	I-EG	Composite	Moderate Snow mixed with Rain	1	75	-	-	76.1	1.5	1.5
E21	28-Mar-23	Clariant Safewing MP II FLIGHT	II	Aluminum	Moderate Snow mixed with Rain	1	75	-	-	74.3	10.6	10.5
E22	28-Mar-23	Clariant Safewing MP II FLIGHT	II	Aluminum	Moderate Snow mixed with Rain	1	75	-	-	74.4	13.0	12.9
E23	28-Mar-23	AllClear AeroClear MAX	III	Aluminum	Moderate Snow mixed with Rain	1	75	-	-	75.5	9.4	9.5
E24	28-Mar-23	AllClear AeroClear MAX	III	Aluminum	Moderate Snow mixed with Rain	1	75	-	-	75.9	8.4	8.5
E25	28-Mar-23	Cryotech Polar Guard Advance	IV-PG	Aluminum	Moderate Snow mixed with Rain	1	75	-	-	78	15.2	15.8
E26	28-Mar-23	Cryotech Polar Guard Advance	IV-PG	Aluminum	Moderate Snow mixed with Rain	1	75	-	-	77.7	15.7	16.3
E27	28-Mar-23	Dow EG106	IV-EG	Aluminum	Moderate Snow mixed with Rain	1	75	-	-	74.3	17.3	17.1
E28	28-Mar-23	Dow EG106	IV-EG	Aluminum	Moderate Snow mixed with Rain	1	75	-	-	74.4	17.6	17.5

Table 3.4: Test Log – Mixed Snow and Freezing Rain Endurance Time Testing at the NRC CEF

Test #	Date	Fluid Name	Fluid Type	Test Surface	Condition	Temp. (°C)	Target Combined Rate (g/dm²/h)	Actual Rate (Snow Only)	Actual Rate (Rain/Freezing Rain Only)	Actual Rate (Combined)	Endurance Time (min)	Adjusted Endurance Time (min)
9	28-Feb-23	Clariant Safewing MP II FLIGHT	II	Aluminum	Light Freezing Rain	-3	25	0	24.7	24.7	43.0	42.5
10	28-Feb-23	Clariant Safewing MP II FLIGHT	II	Aluminum	Light Freezing Rain	-3	25	0	25.3	25.3	43.3	43.8
11	28-Feb-23	AllClear AeroClear MAX	III	Aluminum	Light Freezing Rain	-3	25	0	24.7	24.7	17.5	17.3
12	28-Feb-23	AllClear AeroClear MAX	III	Aluminum	Light Freezing Rain	-3	25	0	25	25	18.0	18.0
13	28-Feb-23	Cryotech Polar Guard Advance	IV	Aluminum	Light Freezing Rain	-3	25	0	25.5	25.5	48.9	49.9
14	28-Feb-23	Cryotech Polar Guard Advance	IV	Aluminum	Light Freezing Rain	-3	25	0	25.5	25.5	49.2	50.2
15	28-Feb-23	Dow EG106	IV	Aluminum	Light Freezing Rain	-3	25	0	25.5	25.5	50.9	51.9
16	28-Feb-23	Dow EG106	IV	Aluminum	Light Freezing Rain	-3	25	0	25.1	25.1	52.4	52.6
41	7-Mar-23	Clariant Safewing MP II FLIGHT	II	Aluminum	Light Snow and Freezing Rain	-3	25	11.6	12.3	23.9	42.2	40.8
42	7-Mar-23	Clariant Safewing MP II FLIGHT	II	Aluminum	Light Snow and Freezing Rain	-3	25	11.6	12.3	23.9	47.3	45.7
43	7-Mar-23	AllClear AeroClear MAX	III	Aluminum	Light Snow and Freezing Rain	-3	25	11.6	12.3	23.9	17.6	17.0
44	7-Mar-23	AllClear AeroClear MAX	III	Aluminum	Light Snow and Freezing Rain	-3	25	11.6	12.3	23.9	20.9	20.2
45	7-Mar-23	Cryotech Polar Guard Advance	IV	Aluminum	Light Snow and Freezing Rain	-3	25	11.6	12.3	23.9	40.8	39.5
46	7-Mar-23	Cryotech Polar Guard Advance	IV	Aluminum	Light Snow and Freezing Rain	-3	25	11.6	12.3	23.9	40.3	39.0
47	7-Mar-23	Dow EG106	IV	Aluminum	Light Snow and Freezing Rain	-3	25	11.6	12.3	23.9	51.4	49.7
48	7-Mar-23	Dow EG106	IV	Aluminum	Light Snow and Freezing Rain	-3	25	11.6	12.3	23.9	51.1	49.3

4. ANALYSIS

This section contains the analytical findings related to the mixed icing conditions testing conducted at the NRC CEF.

4.1 Mixed Snow and Freezing Fog Testing

This subsection describes the analytical findings related to the different testing sub-objectives.

Each test grouping contained snow-only tests, which served as the primary analytical baseline for the mixed snow and freezing fog tests. For each analytical grouping, the mixed condition test endurance times were compared to the baseline snow-only endurance times, and their relative performance was expressed as a ratio to assess the impact of the added freezing fog precipitation on the fluid performance. The ratio calculation is as follows:

$$\textit{Relative Performance Ratio (\%)} = \frac{\textit{Adjusted Mixed Condition Test Endurance Time}}{\textit{Adjusted Snow-Only Test Endurance Time}}$$

The relative performance ratio is referred to as the "Ratio" in the subsequent analysis subsections.

4.1.1 Type I Testing (Improved Methodology)

The endurance time test results for the Type I mixed snow and freezing fog fluid tests are summarized in Table 4.1. For each row, the ratio represents the relative performance of the Type I fluid in the mixed snow and freezing fog condition as compared to the corresponding snow-only baseline (see Figure 2.3).

The Type I mixed snow and freezing fog tests showed comparable performance versus the snow-only baseline tests, with an overall average ratio of 104 percent across all tests conducted. Tests on aluminum surfaces produced an average ratio of 109 percent and a minimum ratio of 64 percent. Tests on composite surfaces produced an average ratio of 109 percent and a minimum ratio of 89 percent.

Table 4.1: Summary of 2022-23 Type I Mixed Snow and Freezing Fog Test Results (Endurance Times)

Test Surface	Temp. (°C)	Target Snow Rate (g/dm²/h)	Target Freezing Fog Rate (g/dm²/h)	Test Count	Average ET Ratio	Minimum ET Ratio
Aluminum	-3	10	2	2	85%	64%
		25	2	2	106%	95%
	-14	10	2	2	101%	99%
		25	2	2	97%	83%
	-25	10	2	2	103%	98%
		25	2	2	102%	80%
All Aluminum Tests				**12**	**99%**	**64%**
Composite	-3	10	2	2	106%	105%
		25	2	2	103%	89%
	-14	10	2	2	99%	93%
		25	2	2	114%	107%
	-25	10	2	2	105%	97%
		25	2	2	130%	117%
All Composite Tests				**12**	**109%**	**89%**
All Tests (All Surfaces)				**24**	**104%**	**64%**

Although the Type I test methodology was improved in 2022-23 to reduce the variance in endurance times introduced by the test process, small variances in the measured endurance times can still occur because of the manual snow application method. These variances are of less concern for the longer-duration Type II/III/IV fluid tests but are more significant when evaluating the shorter-duration Type I tests.

To evaluate the effect of the application cycles, or "snow bursts," an additional analysis was done comparing the number of individual application cycles occurring in each test until failure was observed. Table 4.2 depicts the Type I mixed snow and freezing fog fluid test results as a function of the snow-only application cycles that occurred over the course of the tests as opposed to the endurance time measured. Expressing the results in this manner still accurately captures the performance of the Type I fluid in the mixed condition while reducing the impact of test process variance.

Table 4.2: Summary of Type I Mixed Snow and Freezing Fog Test Results (Application Cycles)

Test Surface	Temp. (°C)	Target Snow Rate (g/dm²/h)	Target Freezing Fog Rate (g/dm²/h)	Test Count	Average Application Cycle Ratio	Minimum Application Cycle Ratio
Aluminum	-3	10	2	2	100%	100%
		25	2	2	150%	100%
	-14	10	2	2	133%	133%
		25	2	2	100%	100%
	-25	10	2	2	108%	100%
		25	2	2	100%	80%
All Aluminum Tests				**12**	**115%**	**80%**
Composite	-3	10	2	2	100%	100%
		25	2	2	150%	100%
	-14	10	2	2	100%	100%
		25	2	2	100%	100%
	-25	10	2	2	100%	100%
		25	2	2	117%	100%
All Composite Tests				**12**	**111%**	**100%**
All Tests (All Surfaces)				**24**	**113%**	**80%**

When evaluating the Type I mixed snow and freezing fog tests by comparing the number of application cycles occurring, the mixed condition tests showed comparable performance versus the snow-only baseline tests, with an overall average ratio of 113 percent across all tests conducted. Tests on aluminum surfaces produced an average ratio of 115 percent and a minimum ratio of 80 percent (this minimum value occurred in only one condition). Tests on composite surfaces produced an average ratio of 111 percent and a minimum ratio of 100 percent.

The test results indicate that Type I fluid endurance time performance in mixed snow and freezing fog is generally equivalent to its snow-only endurance time performance in corresponding conditions. Some examples were observed where the mixed condition test produced a shorter endurance time result, though when the number of snow application cycles were considered instead of the measured endurance times, there was only one mixed condition test that produced a shorter result than its corresponding baseline.

The current guidance for use of Type I fluids in mixed snow and freezing fog conditions is to use a HOT equal to 50 percent of the corresponding snow-only generic Type I HOT. The test results obtained with the new methodology suggest that there may be potential to refine this guidance to provide a greater proportion of the snow-only generic times in conditions of mixed snow and freezing fog. Additional data collection with Type I fluids using the updated methodology is recommended to validate the research findings.

4.1.2 Modified Snow-Only Baseline Testing

Snow-only baseline tests were conducted using the new methodology (fog sprayer deactivated during baseline test), and the endurance time test results were compared to those obtained when the same fluids were tested in 2021-22 using the previous baseline test methodology (see TP 15540E [1]).

For each temperature and rate combination, two tests were conducted with each of the Type II, Type III, and Type IV fluids used in the testing.

Table 4.3 summarizes the results of the 2022-23 snow-only baseline tests versus the corresponding 2021-22 snow-only baseline tests.

Table 4.3: 2022-23 Snow-Only Baseline Results vs. 2021-22 Snow-Only Baseline Results with Type II, III, and IV Fluids

Temp. (°C)	Precipitation Rate (g/dm²/h)	Test Count	Average Change in ET (2022-23 vs. 2021-22)
-3	10	8	-17%
	25	8	-2%
-14	10	8	-32%
	25	8	-13%
-25	10	8	-13%
	25	8	-12%
All Tests		**48**	**-15%**

The snow-only baseline tests performed using the 2022-23 methodology produced endurance times that were, on average, 15 percent shorter than those performed using the 2021-22 methodology. The longer baseline test results seen in 2021-22 are believed to be the result of the active air spray from the fog sprayer disrupting the snow distribution during application of precipitation, resulting in longer than expected endurance times. If this is the case, the previous methodology may have produced baseline test results that resulted in overly conservative guidance.

During the 2021-22 mixed snow and freezing fog endurance time testing, the worst recorded Type II/III/IV fluid performance in mixed snow and freezing fog was equal to 54 percent of the equivalent snow-only baseline time. If the 2022-23 baseline times were used instead, this value would improve to 70 percent. Given that the minimum performing test was a critical factor in determining the HOT guidance, this could have significant implications in future guidance development.

Consideration should be given to conducting additional runs of the snow-only baseline tests using the new test methodology to confirm that the methodology produces repeatable results. If this is the case, consideration should be given to re-evaluating the mixed snow and freezing fog data collected in 2021-22 using the new baseline data to potentially provide longer HOTs.

4.1.3 Testing with Reduced Fog Rates

Endurance time tests were conducted with Type II, III, and IV fluids in mixed snow and freezing fog at target rates of 10 g/dm²/h for snow and 1 g/dm²/h (instead of 2 g/dm²/h) for freezing fog to evaluate the effect of testing with a reduced fog rate. All tests were conducted at a temperature of -3°C.

The results of the reduced fog rate tests were compared to the corresponding snow-only baseline tests from 2021-22 to produce performance ratios. These ratios were then compared to those calculated from tests conducted in mixed snow and freezing fog at target rates of 10 g/dm²/h for snow and 2 g/dm²/h for freezing fog to determine the impact of reducing the fog rate. These results are summarized in Table 4.4.

Table 4.4: Reduced Fog Rate Mixed Snow and Freezing Fog Endurance Times vs. 2021-22 Results

	2022-23 Results SN = 10, ZF = 1 at -3°C			2021-22 Results SN = 10, ZF = 2 at -3°C		
Fluid	**Test Count**	**Average Ratio**	**Minimum Ratio**	**Test Count**	**Average Ratio**	**Minimum Ratio**
Safewing MP II FLIGHT (Type II)	2	122%	120%	1	109%	109%
AeroClear MAX (Type III)	2	73%	69%	1	76%	76%
Polar Guard Advance (Type IV)	2	70%	65%	2	67%	65%
EG106 (Type IV)	2	71%	66%	2	63%	62%
All Tests	**8**	**84%**	**65%**	**6**	**74%**	**62%**

The average performance ratio measured was 84 percent for the reduced fog rate tests; the minimum performance ratio for this group was 65 percent. These values represent slight increases over those noted for the normal fog rate tests conducted in 2021-22 (average ratio 74 percent, minimum ratio 62 percent), which suggests that testing at a reduced fog rate will produce mixed condition test results that are closer to their snow-only baseline results.

Additional mixed snow and freezing fog testing at reduced fog rates will be necessary in the future to characterize the impacts across the full range of precipitation rates and temperatures.

Photo 4.1 depicts an example of a failed Type IV fluid from the reduced fog rate tests. Additional high-resolution photos and video of all tests conducted have been provided to TC in electronic format and can be made available upon request.

4.1.4 Heavy Snow Rate Testing

Endurance time tests were conducted using heavy snow rates (50 and 100 g/dm²/h) in both snow-only and mixed snow and freezing fog conditions to evaluate whether the addition of freezing fog has an impact on fluid endurance time performance in snow at high rates.

The snow-only baseline tests were conducted using the 2021-22 methodology where the fog sprayer was positioned over the stand spraying air.

4.1.4.1 Type I Results – Heavy Snow Rate Testing

All Type I tests were conducted using the improved Type I testing methodology described in Subsection 2.2.1.1.

The heavy snow rate test results for Type I fluids are summarized in Table 4.5. Performance ratios for Type I tests have been described as a function of snow application cycles as opposed to endurance times (see Subsection 4.1.1).

Table 4.5: Type I Mixed Snow and Freezing Fog Test Results (Heavy Snow Rates)

Test Surface	Temp. (°C)	Target Snow Rate (g/dm²/h)	Target Freezing Fog Rate (g/dm²/h)	Test Count	Average Application Cycle Ratio	Minimum Application Cycle Ratio
Aluminum	-3	50	2	2	200%	100%
		100	2	2	150%	100%
All Aluminum Tests				**4**	**175%**	**100%**
Composite	-3	10	2	2	100%	100%
		25	2	2	100%	100%
All Composite Tests				**4**	**100%**	**100%**
All Tests (All Surfaces)				**8**	**138%**	**100%**

The addition of freezing fog to heavy snow did not have a worsening effect on the measured Type I fluid performance. There were no instances in which the mixed snow and freezing fog condition produced a worse result than the corresponding snow-only baseline.

4.1.4.2 Type II/III/IV Fluid Results – Heavy Snow Rate Testing

The heavy snow rate test results for Type II, Type III, and Type IV fluids are summarized in Table 4.6.

Table 4.6: Type II, Type III, and Type IV Mixed Snow and Freezing Fog Test Results (Heavy Snow Rates)

Fluid	Temp. (°C)	Target Snow Rate (g/dm²/h)	Target Freezing Fog Rate (g/dm²/h)	Test Count	Average ET Ratio	Minimum ET Ratio
Safewing MP II FLIGHT	-3	50	2	2	130%	124%
		100	2	2	109%	106%
AeroClear MAX	-3	50	2	6	92%	80%
		100	2	2	112%	107%
Polar Guard Advance	-3	50	2	2	126%	116%
		100	2	2	140%	133%
EG106	-3	50	2	2	121%	106%
		100	2	2	112%	110%
All Tests				**8**	**138%**	**80%**

In most cases, the addition of freezing fog resulted in endurance times that were longer than the corresponding snow-only baselines. The only exceptions were the tests conducted with the Type III fluid at a target rate of 50 + 2, which consistently produced results that were slightly shorter than the corresponding baseline. This test was repeated a total of six times to confirm that the observed results were repeatable.

The results suggest that the addition of freezing fog to heavy snow has a negligible negative effect on the measured Type II/III/IV fluid performance in most but not all cases. If the rate is sufficiently high (100 g/dm²/h), then it is likely that the impact of the freezing fog would be negligible.

4.2 Mixed Snow and Rain Testing

Endurance time tests were conducted in mixed snow and rain at a series of different rate combinations to support the development of HOT guidance for the mixed conditions of moderate snow mixed with rain and moderate rain mixed with snow. All mixed condition tests were conducted at a temperature of 0°C.

The results of the mixed condition tests were compared to rain on a cold-soaked wing baseline tests to produce relative performance ratios.

4.2.1 Type I Test Results – Mixed Snow and Rain Testing vs. Rain on CSW

The Type I results are summarized below in Table 4.7.

Table 4.7: Type I Test Results Mixed Snow and Rain vs. Rain on CSW

Test Surface	Temp. (°C)	Target Snow Rate (g/dm²/h)	Target Rain Rate (g/dm²/h)	Test Count	Average ET Ratio	Minimum ET Ratio
Aluminum	0	25	13	2	254%	249%
		25	25	2	280%	249%
		25	50	4	356%	348%
		10	65	2	534%	497%
		3	72	2	1423%	1393%
All Aluminum Tests				**12**	**534%**	**249%**
Composite	0	25	13	2	163%	124%
		25	25	2	163%	124%
		25	50	4	299%	207%
		10	65	2	217%	165%
		3	72	2	2171%	1654%
All Composite Tests				**12**	**552%**	**124%**
All Tests (All Surfaces)				**24**	**543%**	**124%**

The minimum ratios for each rate combination are shown in Figure 4.1 to provide a visual representation of the trend in Type I fluid performance as the rates of the constituent precipitation types are adjusted.

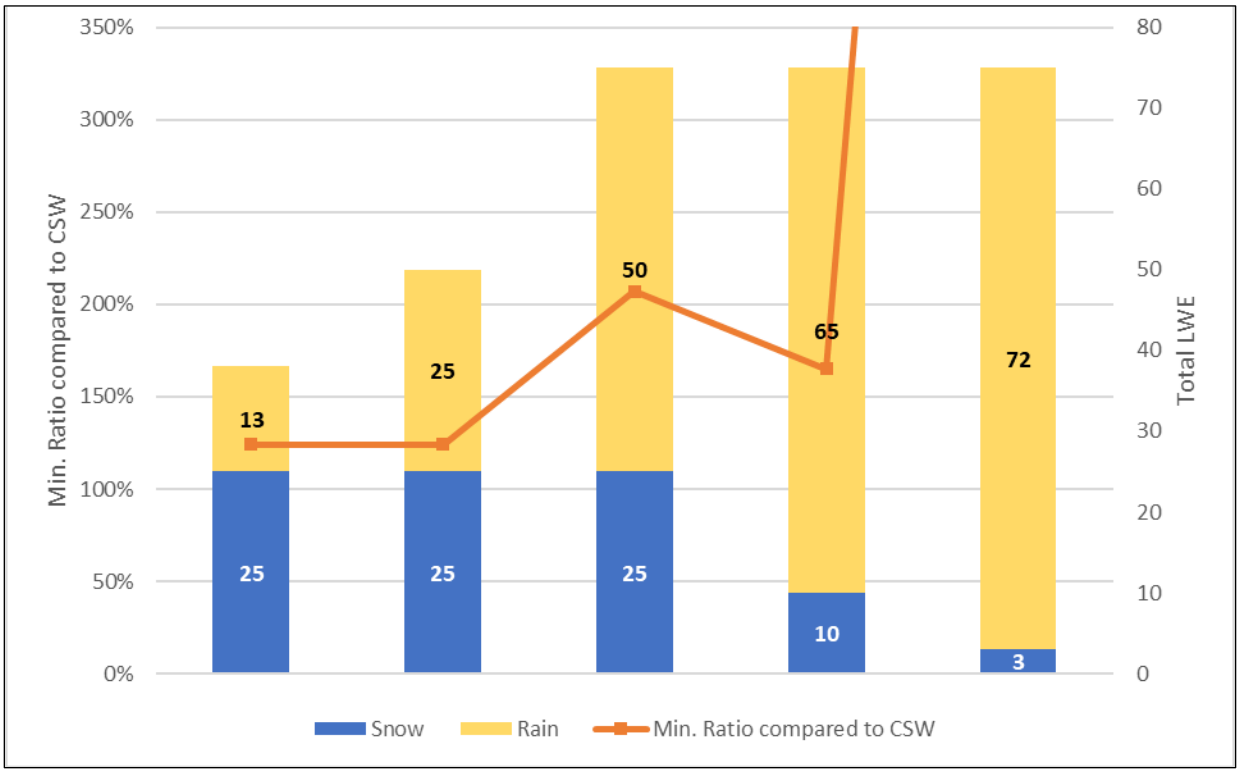


Figure 4.1: Worst-Case Type I Performance Ratio at Different Rain and Snow Rate Combinations

In all rate combinations tested, the Type I fluids performed better in mixed rain and snow (or mixed snow and rain) than in the corresponding rain on a cold-soaked wing baselines. The worst observed performance ratio across all Type I tests was 124 percent, seen in both "Moderate Snow mixed with Rain" combinations (25 + 25 and 25 + 13).

The data collected suggests that the rain on a cold-soaked wing HOTs may be suitable for use with Type I fluids in a mixed snow and rain scenario; however, additional data collection should be considered to better characterize this mixed condition.

4.2.2 Type II/III/IV Test Results - Mixed Snow and Rain Testing vs. Rain on CSW

The Type II, Type III, and Type IV fluid results are summarized below in Table 4.8.

Table 4.8: Type II, Type III, and Type IV Test Results Mixed Snow and Rain vs. Rain on CSW

Fluid	Temp. (°C)	Target Snow Rate (g/dm²/h)	Target Rain Rate (g/dm²/h)	Test Count	Average ET Ratio	Minimum ET Ratio
Safewing MP II FLIGHT (Type II)	0	25	13	2	313%	305%
		25	25	2	221%	213%
		25	50	2	130%	121%
		10	65	2	132%	128%
		3	72	2	174%	171%
AeroClear MAX (Type III)	0	25	13	2	174%	161%
		25	25	2	136%	127%
		25	50	2	110%	106%
		10	65	2	120%	119%
		3	72	2	130%	129%
Polar Guard Advance (Type IV)	0	25	13	2	257%	252%
		25	25	2	205%	188%
		25	50	2	93%	93%
		10	65	2	82%	77%
		3	72	2	113%	111%
EG106 (Type IV)	0	25	13	2	224%	212%
		25	25	2	185%	183%
		25	50	2	116%	113%
		10	65	2	96%	90%
		3	72	2	150%	127%
All Tests				**40**	**158%**	**77%**

The minimum ratios for each rate combination are shown in Figure 4.2 to provide a visual representation of the trend in the thickened fluid performance as the rates of the constituent precipitation types are adjusted.

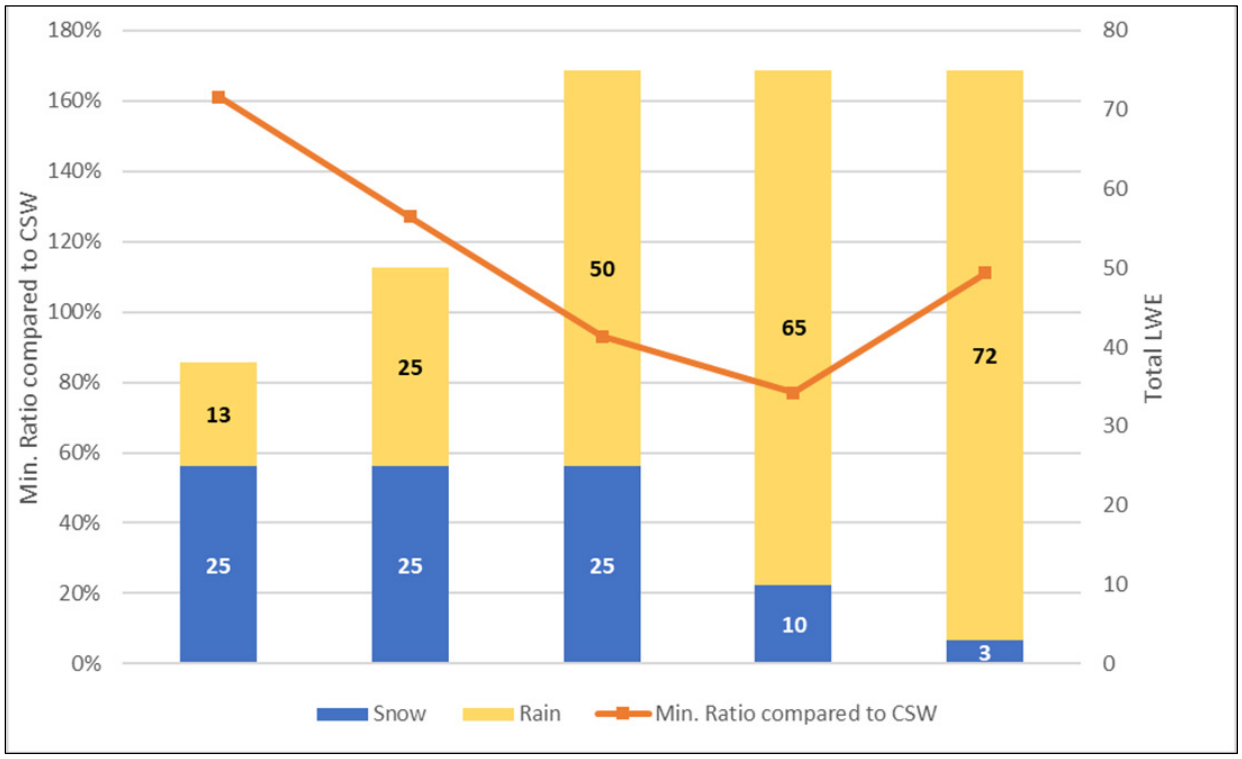


Figure 4.2: Worst-Case Type II/III/IV Performance Ratio at Different Rain and Snow Rate Combinations

The Type II/III/IV fluids showed a decreasing trend in fluid performance in the mixed condition compared to the baseline tests as the rain rate was increased, with the worst observed performance occurring at the "Rain 65 + Snow 10" combination. Fluid performance improved as the rain rate was increased beyond 65 (with the snow rate being decreased accordingly).

The worst observed performance ratio across all Type II, Type III, and Type IV tests was 77 percent, observed with Polar Guard Advance at the "Moderate Rain mixed with Snow" combination of "Rain 65 + Snow 10."

The data collected indicates that fluid performance in mixed rain and snow is somewhat comparable to fluid performance in a rain on a cold-soaked wing condition; the presence of cases where the performance in the mixed condition fell short of the baseline performance suggests that additional data collection would be needed to further characterize this condition for guidance development.

Photo 4.2 depicts an example of a failed Type IV fluid from the moderate snow and rain tests (snow rate of 25 g/dm²/h, rain rate of 25 g/dm²/h). Additional high-resolution photos and video of all tests conducted have been provided to TC in electronic format and can be made available upon request.

4.3 Mixed Freezing Rain and Snow Testing

Endurance time tests were conducted with Type II, III, and IV fluids in mixed freezing rain and snow at target rates of 13 g/dm²/h for freezing rain and 12 g/dm²/h for snow to evaluate the applicability of light freezing rain HOTs to the mixed condition. All tests were conducted at a temperature of -3°C.

The results of the mixed condition tests were compared to freezing rain–only baseline tests to produce relative performance ratios. These results are summarized in Table 4.9.

Table 4.9: Test Results - Mixed Freezing Rain and Snow vs. Light Freezing Rain

Fluid	Temp. (°C)	Target Freezing Rain Rate (g/dm²/h)	Target Snow Rate (g/dm²/h)	Test Count	Average ET Ratio	Minimum ET Ratio
Safewing MP II FLIGHT	-3	13	12	2	99%	94%
AeroClear MAX	-3	13	12	2	104%	95%
Polar Guard Advance	-3	13	12	2	78%	77%
EG106	-3	13	12	2	94%	93%
All Tests				**8**	**94%**	**77%**

The endurance times measured in the mixed freezing rain and snow tests were generally comparable to the freezing rain-only baseline endurance times, with an average performance ratio of 94 percent across all fluids tested. The minimum performance ratio noted was 77 percent with Polar Guard Advance, a PG-based Type IV fluid.

Although the preliminary data indicates that fluid performance in mixed freezing rain and snow is comparable to freezing rain alone (assuming similar liquid water equivalent [LWE] in both cases), the presence of cases where the performance in the mixed condition fell short of the baseline performance suggests that additional data collection would be needed to further characterize this condition for guidance development.

Photo 4.3 depicts an example of a failed Type IV fluid from a mixed freezing rain and snow test run. Additional high-resolution photos and video of all tests conducted have been provided to TC in electronic format and can be made available upon request.

4.4 Consideration for Changes to Holdover Time Guidance Material

The results of the mixed icing tests were reviewed and discussed with TC/FAA to determine the best path forward for further mixed icing HOT guidance development.

Ultimately, due to the limited data collected for each of the different research goals, it was determined that additional data collection should be conducted in the 2023-24 season to validate the findings of the 2022-23 research prior to making any changes to the published mixed icing conditions guidance.

Photo 4.1: Type IV Fluid Failure Example in Mixed Snow and Freezing Fog

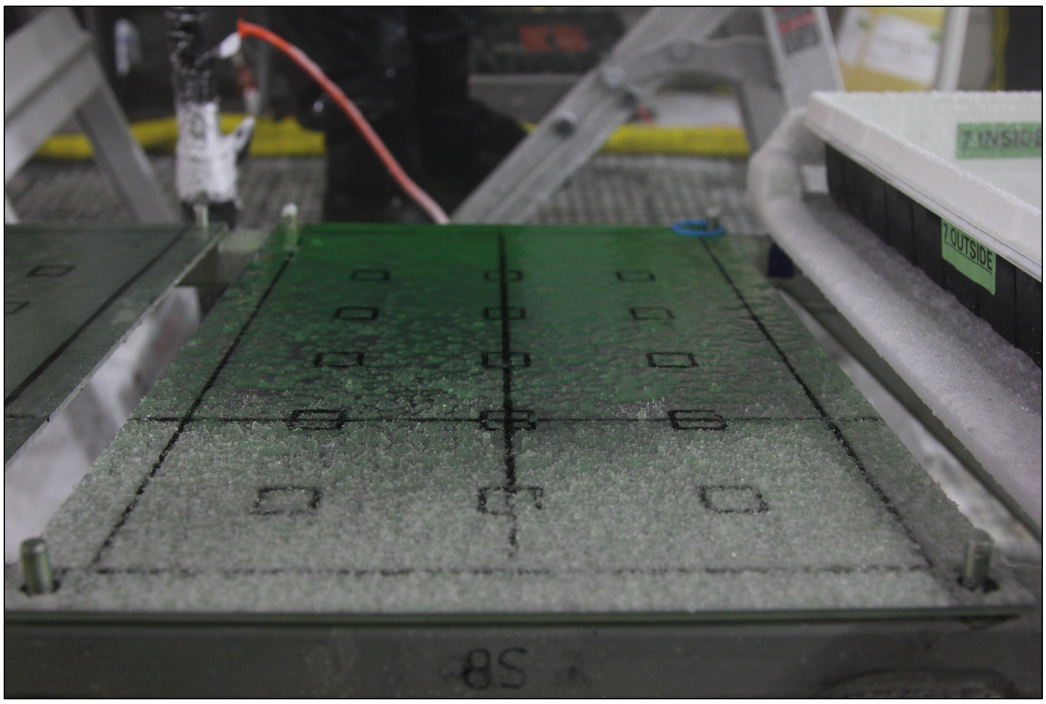


Photo 4.2: Type IV Fluid Failure Example in Mixed Snow and Rain

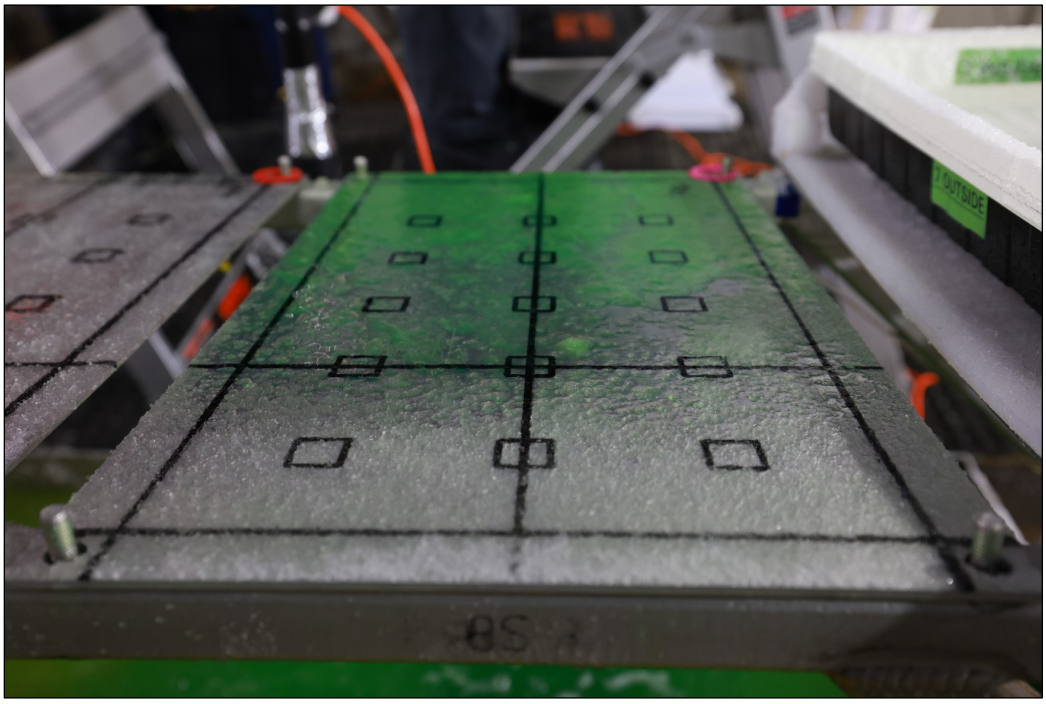
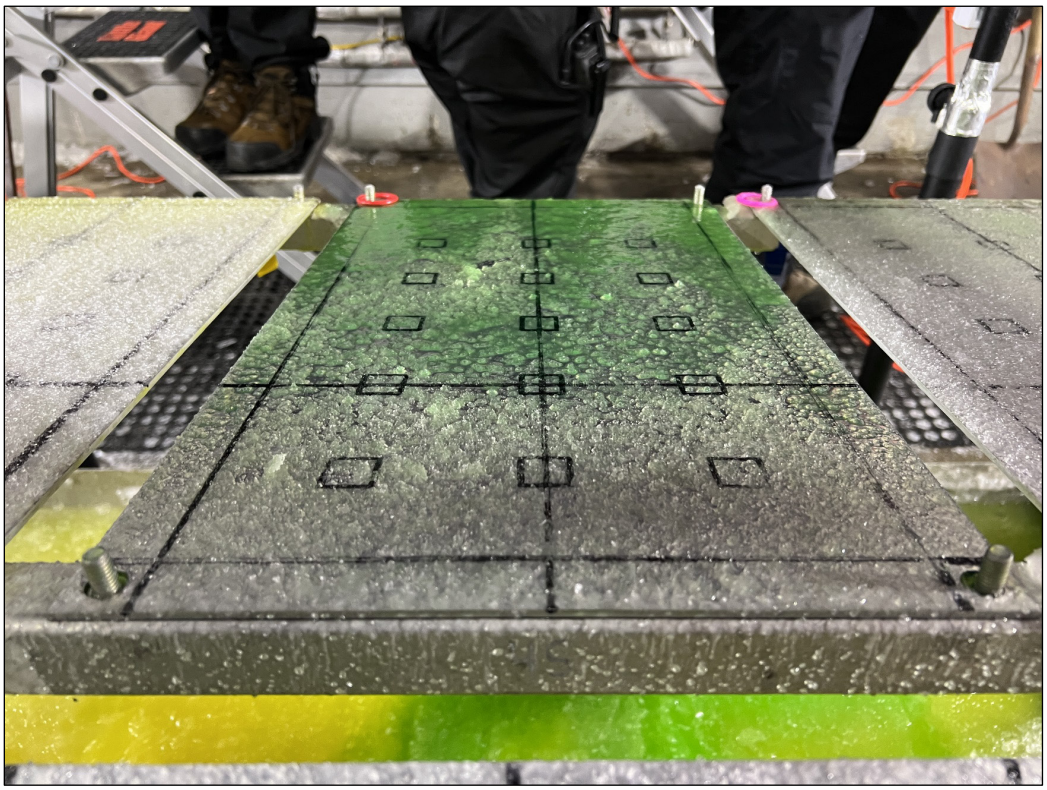


Photo 4.3: Type IV Fluid Failure Example in Mixed Snow and Freezing Rain



5. CONCLUSIONS

The following conclusions were derived from the mixed icing conditions research conducted in the winter of 2022-23.

5.1 Mixed Snow and Freezing Fog Testing

This subsection contains the analytical conclusions related to the mixed snow and freezing fog research sub-objectives.

5.1.1 Type I Testing (Improved Methodology)

The test results obtained with the updated methodology show that Type I fluid endurance time performance in mixed snow and freezing fog is generally equivalent to its snow-only endurance time performance in corresponding conditions. Some examples were observed where the mixed condition test produced a shorter endurance time result, though when the number of snow application cycles were considered instead of the measured endurance times, there was only one mixed condition test that produced a worse result than its corresponding baseline.

The results indicate that there may be potential to refine this guidance to provide a greater proportion of the snow-only generic times in conditions of mixed snow and freezing fog for Type I fluids.

5.1.2 Modified Snow-Only Baseline Testing

Snow-only baseline tests were conducted using a modified methodology (fog sprayer inactive during the baseline test), and the endurance time test results were compared to those obtained when the same fluids were tested in 2021-22.

The snow-only baseline tests performed using the 2022-23 methodology produced endurance times that were, on average, 15 percent shorter than those performed using the 2021-22 methodology. This suggests that the previous methodology may have produced baseline test resulting in guidance that was overly conservative. With further validation, this could support revisiting the existing guidance for mixed freezing fog and snow and result in longer HOTs.

5.1.3 Testing with Reduced Fog Rates

Endurance time tests were conducted with Type II, III, and IV fluids in mixed snow and freezing fog at target rates of 10 g/dm²/h for snow and 1 g/dm²/h for freezing fog to evaluate the effect of testing with a reduced fog rate.

The average performance ratio measured was 84 percent for the reduced fog rate tests; the minimum performance ratio for this group was 65 percent. These values represent slight increases over those noted for the normal fog rate tests conducted in 2021-22 (average ratio 74 percent, minimum ratio 62 percent). This suggests that testing at a reduced fog rate will produce mixed condition test results that are closer to their snow-only baseline results.

5.1.4 Heavy Snow Rate Testing

The heavy snow rate test results show that the addition of freezing fog to heavy snow has a negligible effect on the measured fluid performance in most but not all cases. If the rate is sufficiently high (100 g/dm²/h), then it is expected that the impact of the freezing fog would be negligible for all fluid types.

5.2 Mixed Snow and Rain Testing

The Type I fluid performance in mixed snow and rain exceeded that of the rain on a cold-soaked wing baseline in all cases tested. This suggests that the rain on a cold-soaked wing HOTs may be suitable for use with Type I fluids in a mixed snow and rain scenario; however, additional data collection should be considered to better characterize this mixed condition. Given that the Type I fluid performance varied significantly from the baseline, other potential baselines should be evaluated as well.

The data collected indicates that Type II/III/IV fluid performance in mixed snow and rain is somewhat comparable to fluid performance in a rain on a cold-soaked wing condition. Several cases where the performance in the mixed condition fell short of the baseline performance were recorded. Additional data collection is recommended to further characterize this condition prior to guidance development.

5.3 Mixed Snow and Freezing Rain Testing

The preliminary data collected indicates that fluid performance in mixed freezing rain and snow is comparable to freezing rain alone (assuming similar LWE in both cases). There are cases, however, where the performance in the mixed condition fell short of the baseline performance. Additional data is needed to further characterize this condition for guidance development.

5.4 Changes to Mixed Icing Guidance

The results of the mixed icing tests were reviewed and discussed with TC/FAA to determine the best path forward for further mixed icing HOT guidance development.

Ultimately, due to the limited data collected for each of the different research goals, it was determined that additional data collection should be conducted in the 2023-24 season to validate the findings of the 2022-23 research prior to making changes to the published mixed icing conditions guidance.

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6. RECOMMENDATIONS

It is recommended that additional mixed icing conditions research be conducted next year to collect the necessary data to complete the testing and guidance development objectives begun in 2022-23.

The priorities for mixed icing conditions testing and development in Winter 2023-24 have been identified in consultation with TC and the FAA and are listed below.

1. Additional data collection in mixed snow and freezing fog with Type I fluids using the improved snow application methodology.
2. Additional runs of snow-only baseline tests using the test methodology developed in 2022-23 to confirm that the methodology produces repeatable results. If this is the case, consideration should be given to re-evaluating the mixed snow and freezing fog data collected in 2021-22 using the new baseline data.
3. Additional data collection in mixed snow and freezing fog testing at reduced fog rates to characterize the impacts across the full range of precipitation rates and temperatures. In addition, testing in mixed snow and mist (a lower-intensity fog spray) will also be considered.
4. Additional data collection in mixed snow and freezing fog with other commercialized fluids to validate the broader applicability of the guidance issued for this condition.
5. Additional data collection in mixed rain and snow to further characterize the condition for guidance development.

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2. APS Aviation Inc., *Aircraft Ground Icing General Research Activities During the 2008-09 Winter*, APS Aviation Inc., Transportation Development Centre, Montreal, December 2009, TP 14936E, XX (to be published).

3. SAE International Aerospace Recommended Practice 5485B, *Endurance Time Test Procedures for SAE Type II/III/IV Aircraft Deicing/Anti-Icing Fluids*, October 2017.

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APPENDIX A

TRANSPORT CANADA
STATEMENT OF WORK EXCERPT –
AIRCRAFT & ANTI-ICING FLUID WINTER TESTING 2022-23

TRANSPORT CANADA
STATEMENT OF WORK EXCERPT –
AIRCRAFT & ANTI-ICING FLUID WINTER TESTING 2022-23

1. Freezing Fog and Snow HOTs – Comparative Testing and Guidance Development – Priority 1

a) Review and refine the existing test methodology and procedure for simulating a combined freezing fog and snow precipitation condition;

b) Conduct comparative endurance time testing at the NRC-CEF in the following conditions (expected 10 days testing at climatic facility):

   i. Simulated Freezing Fog;

   ii. Simulated Snow; and

   iii. Simulated Freezing Fog and Snow (combined);

c) Conduct complementary testing at alternative indoor or outdoor test facilities, as required;

d) Analyse comparative test results;

e) Hold technical discussions with TC/FAA and develop necessary guidance material;

f) Prepare presentation for SAE G-12; and

g) Prepare a report.

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APPENDIX B

PROCEDURE:
EVALUATION OF ENDURANCE TIMES IN SIMULATED SNOW AND FREEZING FOG WITH SAE TYPE I, II, III, AND IV DE/ANTI-ICING FLUIDS

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PROCEDURE:

EVALUATION OF ENDURANCE TIMES IN SIMULATED SNOW AND FREEZING FOG WITH SAE TYPE I, II, III, AND IV DE/ANTI-ICING FLUIDS

Winter 2021-22

Prepared for:

Transport Canada
Innovation Centre

In cooperation with:

Federal Aviation Administration
William J. Hughes Technical Center

Transport Canada
Civil Aviation

Federal Aviation Administration
Flight Standards – Air Carrier Operations

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February 24, 2022
Final Version 1.0

EVALUATION OF ENDURANCE TIMES IN SIMULATED SNOW AND FREEZING FOG WITH SAE TYPE I, II, III, AND IV DE/ANTI-ICING FLUIDS

Winter 2021-22

1. BACKGROUND

METARs are provided for most airports on an hourly basis, with special reports (referred to as SPECIs) issued whenever a significant change in weather occurs. When aircraft are operating in adverse winter conditions, the METAR reported weather conditions may not always have a corresponding condition in the Holdover Time (HOT) guidance to allow for safe departure, and this is especially true for mixed conditions.

Fog (FG) is treated as an obscuration as it is defined as very small droplets suspended in the air that do not fall to the ground; therefore, no precipitation rate is reported for FG by the Federal Meteorological Handbook No. 1 (FMH1) or the Manual of Surface Weather Observations Standards. While FG is not considered a precipitation condition, the droplets may deposit on aircraft surfaces and, for that reason, freezing fog (FZFG) HOTs were developed. At the 1997 Chicago SAE G-12 HOT Committee meeting, it was agreed that the lower and upper HOTs for FZFG should be evaluated at rates of 5 g/dm2/h and 2 g/dm2/h, respectively. The FZFG HOTs currently apply only when FZFG is reported alone, and no HOTs exist for FZFG reported with other precipitation conditions.

Industry expressed concerns with HOT guidance related to conditions of snow mixed with freezing fog (SNFZFG) and provided details in an Airlines for America presentation submitted to the Federal Aviation Administration (FAA). As a result, the FAA and Transport Canada (TC), requested that APS Aviation Inc. (APS) conduct endurance time testing to support the development of guidance for HOTs in mixed snow and freezing fog conditions.

2. OBJECTIVE

The objective of this testing is to conduct endurance time testing in simulated mixed snow and freezing fog conditions.

To satisfy this objective, a series of flat plate tests will be conducted at the National Research Council Canada (NRC) Climatic Engineering Facility (CEF) in a variety of conditions including both snow and freezing fog, both individually and mixed. The data collected will be used to support the development of HOT guidance material for operations in mixed snow and freezing fog conditions.

3. TIMING AND TEST PLAN

A minimum of 10 days of testing are expected, with the possibility of adding 2-4 additional days of testing.

Testing will be conducted at the NRC during regular daytime hours of 8:00 am to 4:00 pm. Extra hours after 4pm will be considered on a day-by-day basis as required and are not expected to exceed 8pm. A test calendar is included in Table 3.1.

Table 3.1: Test Calendar

Week of	Sun	Mon	Tue	Wed	Thurs	Fri	Sat
20-Feb-22							
27-Feb-22		Drive to YOW APS Setup & Training	Rate Calibration and Fluid Variability Calibration	Fluid Variability Calibration	Freezing Fog, Snow & Snow + Freezing Fog Testing		
06-Mar-22		Freezing Fog, Snow & Snow + Freezing Fog Testing					
13-Mar-22		Freezing Fog, Snow & Snow + Freezing Fog Testing	Testing Likely Possible Spare Day	Testing Likely Possible Spare Day	Spare Day	Spare Day	
20-Mar-22							

Legend

Drive to YOW APS Setup, Training, and Snow Making	APS drive to YOW APS to setup equipment, setup remote vieweing cameras, conduct training for new setup, and begin the production of Snow for the Calibration Day.
Rate Calibration and Fluid Variability Calibration	APS to conduct rate calibration for the Snow, Freezing Fog & Snow + Freezing Fog, and calibrate the Test Stand with Full Plates & Half Plates (-3°C)
Freezing Fog, Snow & Snow + Freezing Fog Testing	Freezing Fog, Snow & Snow + Freezing Fog Testing with R&D Fluids (Starting at -14°C). NRC Arrival: 8:00am Begin Testing: 8:30am
Testing Likely Possible Spare Day	Testing is likely to happen, however it could be a Spare Day
Spare Day	Spare Day

4. TEST PLAN

The NRC CEF is a temperature-controlled facility. Prior to testing, the desired temperature will be set by NRC staff and allowed to stabilize.

Representative Type I/II/III/IV propylene glycol and ethylene glycol-based fluids in the 100/0 dilution (standard mix or 10-degree buffer for Type I) shall be evaluated in a variety of conditions including both snow and freezing fog, both individually and mixed.

Figure 4.1 demonstrates the basic test parameters for the different test sets that will be simulated in mixed light snow and freezing fog, and mixed moderate snow and freezing fog. The NRC CEF provides adequate room for APS to setup two separate test stands shown in Figure 4.2. One test stand (main stand) will be used for the solo condition of Freezing Fog, and the mixed condition of Snow and Freezing Fog. The additional test stand (side stand) will be used for the solo condition of Snow.

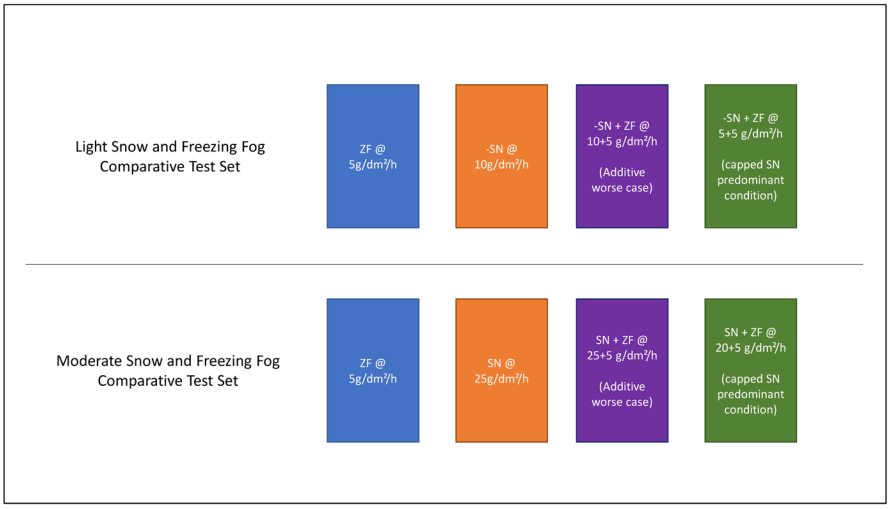


Figure 4.1: Comparative Test Sets

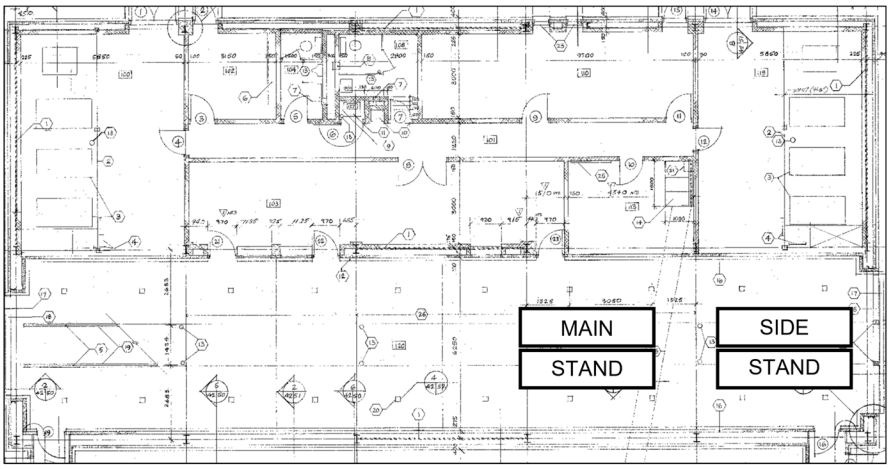


Figure 4.2: Test Stand Setup (NRC CEF)

A detailed test matrix (subject to change) is included in Attachment 3. As this testing is exploratory, changes to the test plan may be proposed and made by APS at the time of testing and will be confirmed by TC/FAA.

NOTE: The numbering of the test runs will be done in a sequential order starting with number 1.

5. TESTING PROCEDURE

The following sections describe the tasks to be performed during each test conducted. The standard HOT testing procedures will be followed and modified as required to accommodate the mixed precipitation testing setup.

5.1 Fluid Application

The steps listed below should be followed for fluid application.

- Hand pour 1L of II, III, or IV fluid at outside air temperature (OAT) or 1L of TI fluid at 20ºC over the test plate. The type of fluid poured on the designated test plate will be decided prior to the beginning of the test).
- Record fluid application time and fluid failure time.
- Measure the brix prior to pouring, the fluid thickness 5 minutes after application, and the brix at time of fluid failure.
- Photograph the fluid as the test continues until fluid failure and 5 minutes after fluid failure.

5.2 Application of Precipitation

The simulated precipitation that can be generated include the following:

- Freezing Fog at a rate of 5g/dm²/h; and
- Snow at rates of 5, 10, 20, or 25 g/dm²/h.

A rate management program will be used to assist in managing the measurement of precipitation rates. To measure the rate of precipitation, APS will use plastic rate pans to collect the snow and freezing fog over a determined period.

5.2.1 Simulated Freezing Fog

Freezing fog is simulated using an NRC developed sprayer assembly providing a large scan area and appropriate spray uniformity over the test area. The scanner consists of a horizontal main shaft supported by two bearings. The actual spray head assembly is shaft-mounted on a rotating scanner, so that one scan covers a lateral running strip of the test area. A stepper motor is synchronized to index the relative

angle of the spray head between scans along an axis perpendicular to the scan axis. This provides two axes of rotation, essentially an x-y plane; one along each axis. Each scan is consecutively indexed to complete the precipitation coverage of the test bed area. This defines one cycle of the spray unit. The scan rate, index angle, and the number of scans per cycle are adjusted, along with the fluid delivery pressures (water and air) to obtain appropriate droplet sizes and precipitation rates. The sprayer system uses compressed air and distilled water to produce freezing fog. The sprayer assembly is shown in Photo 5.1.

Photo 5.1: Sprayer Assembly

5.2.2 Simulated Snow

Calibration work is being performed during the winter of 2021-22 with the purpose of obtaining the dispenser's distribution footprint over two test stands based on the historical data used to support the wind tunnel tests. A series of tests will be performed in low wind conditions using rate pans. Pre-measured amounts of snow will be dispersed over this area and the amount collected by each pan will be recorded. A distribution footprint of the dispenser will be attained and efficiency for the dispenser computed.

5.2.2.1 Dispensing Snow for NRC Tests

Using the results from these calibration tests, a decision was made to use two dispensers on each side of the two test stands; each of the four dispensers are moved to four different positions along each edge during the dispensing process. Figure 5.1, and Figure 5.2, demonstrate the setup of the dispensers in relation to the stand. Attachment 1 display the data sheets that will be used during testing in the

wind tunnel. These data sheets will provide all the necessary information related to the amount of snow needed, effective rates, and dispenser positions.

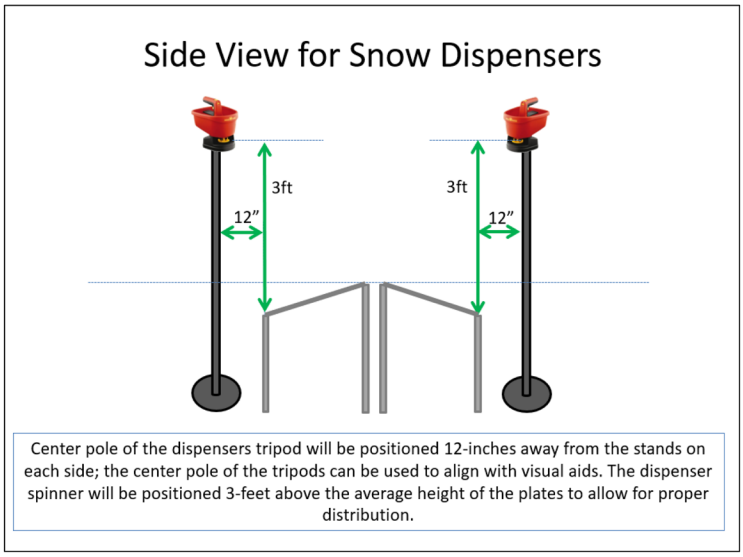


Figure 5.1: Side View of Positioning of Dispenser Relative to the Wing – Snow

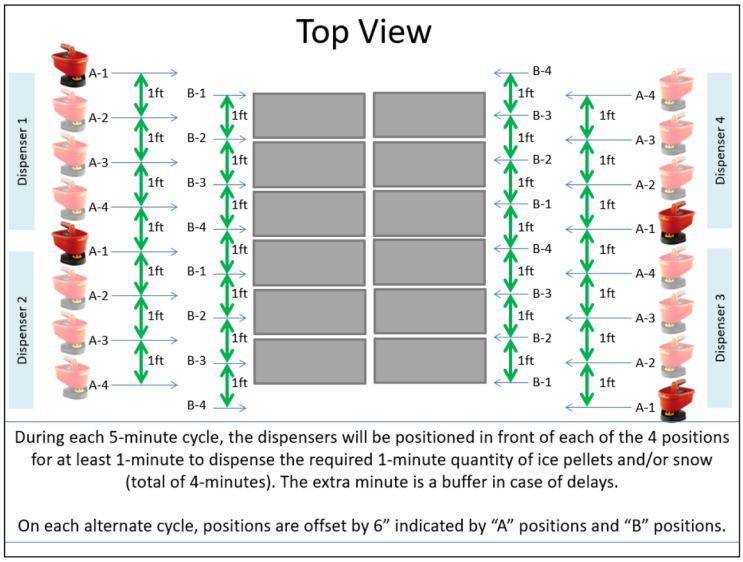


Figure 5.2: Top View of Positioning of Dispenser Relative to the Test Stands

5.3 At the End of Each Test Day

At the end of the testing day, the following tasks will need to be completed:

- Fluid clean-up and disposal (YOWs);
- Download plate temperature data. Note: an initial analysis should be done of the first few days of testing to explore the effects of latent heat (BB/DL);
- Update the log of completed tests (PK); and
- Testing debrief meeting with TC and FAA (MR/JD).

6. PERSONNEL

Six APS staff members are required for the tests at the NRC cold chamber. Six additional persons will be required from Ottawa for making and dispensing the snow. One additional person from Ottawa will be required to photograph the testing. Table 6.1 demonstrates the personnel required and their associated tasks.

Fluid and snow applications will be performed by APS/YOW personnel at the NRC cold chamber. NRC personnel will operate the NRC wind tunnel and operate the freezing fog sprayer (if requested).

Table 6.1: Personnel List

APS Personnel List	
Person	**Responsibility**
Marco Ruggi (MR)	Project Manager / TC FAA Liaison
John D'Avirro (JD)	SME and Remote Support
Benjamin Bernier (BB)	Main Stand Lead / Data Collection / Fluid Manager (inventory and application) / YOW Pers. Manager / Rate Manager
Diana Lalla (PK)	Side Stand Lead - Data Collection / Rate Support
Peter Kitchener (PK)	Documentation (Forms, logs, etc.) and Coordination / Snow Dispensing and Production Manager
Shahdad Movaffagh (SM)	Remote Camera Setup
YOW Personnel List	
Photo (SM)	Photography / Remote Camera Maintenance
Steve Baker (STB)	General Support Lead
YOW 1	Fluids / Snow Manufacturing / Dispensing
YOW 2	Fluids / Snow Manufacturing / Dispensing
YOW 3	Fluids / Snow Manufacturing / Dispensing
YOW 4	Fluids / Snow Manufacturing / Dispensing
YOW 5	Snow Manufacturing

7. FLUIDS

Mid-viscosity samples of Type II, III, IV EG and IV PG fluid will be used in the snow and freezing fog tests. In addition to the mid-viscosity samples, Type I fluid will be used in the snow and freezing fog tests.

The required fluids are shown in Table 7.1. Fluids that will be used the first day of testing should be placed inside the chamber overnight at the NRC. Fluids should be stored at their test temperature, either inside the chamber or in coolers, a minimum of 12 hours prior to testing.

Table 7.1: Fluid Available for Snow & Freezing Fog Tests

Fluid	Type	EG PG	APS Fluid Code	Dilution	Jugs (L)	Pour Containers (1L)	Total Fluids (L)
Calibration Fluids							
AeroClear MAX	III	EG	063A	100/0	7 x 20L	24 (empty)	160
Test Fluids							
DOW PG ADF Concentrate	I	PG	097A	Conc.	5 x 20L	16 (empty)	100
Safewing MP II FLIGHT	II	PG	023A	100/0	7 x 20L	16	160
AeroClear MAX	III	EG	067A	100/0	7 x 20L	16	160
Polar Guard Advance	IV	PG	090A	100/0	7 x 20L	16	160
EG106	IV	EG	096A	100/0	7 x 20L	16	160
Total Fluids							**900**

8. EQUIPMENT

Table 8.1 provides a list of required equipment.

Table 8.1: Equipment List

EQUIPMENT	STATUS		EQUIPMENT	STATUS
General Support and Testing Equipment			**Camera Equipment**	
Brixometer x 3			4K IP Camera with tripod mounts x 2	
Cart (IKEA) x 2			4K IP Camera Zoomed Lens with tripod mounts x 2	
Clock (Large digital) x 2			Ethernet Cable (150ft) x 5	
Extension cords (power bars x 6 + reels x 4)			Manfroto arms and mounts suitcase	
Flashlights x 2			Monitor with VGA cable	
Fluids (separate table)			NVR Receiver	
Fluid carrying cases x 4			Osmo/GoPro Cameras + accessories	
Folding table x 1 (small)			Power Cables for monitor and receiver x 2	
Freezers x 3			Remote camera system (See SM for details)	
Gloves: rubber/winter (a lot)			ZTE with large internet plan	
Gloves: cotton (a lot)				
Gloves: latex (a lot)			**Snow Fabrication Equipment**	
Hard water chemicals x 5 premixes			Adherence Probes Kit	

Table 8.1: Equipment List (cont'd)

EQUIPMENT	STATUS		EQUIPMENT	STATUS
Ice Pic			Blenders x 12 in good condition	
Inclinometer (yellow level) x 2			Folding tables (2 large, 1 small)	
Isopropyl x 6			Ice bags	
Ladders x 4			Snow box supports for railing x4	
Lock for truck			Snow control wires and boxes	
Marker for Waste x 2			Snow dispersers x 12	
Measuring Cups x 3			Sieves (solid base, 1.4 mm, 4 mm) x 2 each	
Paper towel (blue shop towel) x 40			Stands for Snow dispensing devices x 6	
Personnel clothing (testing coats/boots)			Snow Styrofoam containers x40	
Pour containers: (1-litre) - 8 empty			Measuring cups (1L + 1cup/smaller)	
Pour containers: (1-litre) - see list of fluids			Sartorius 35KG scale	
Pots and Sous Vide for Type I x 2			Rubber Mats x 4	
Printer & Ink Cartridge			Wooden Spoons	
Rain Suits x 5				
Rate Pan (aluminum HOT) x1				
Rate Pans (white plastic) x all				
Sample bottles x 6				
Sartorius Scales x 2				
Scrapers x 14			**Office Equipment**	
Shop Vac + 2x18L open top pails			Blank Waterproof labels (1 page)	
Smart button kits x 2 + extension wire			Calculators x 3	
Squeegees x 4 (small)			Clip boards x 5	
Steel Frame Canopy x4 (5x5)			Data Forms (on water phobic paper)	
Tape: Duct tape x 2			Dry eraser markers	
Tape: Electrical tape x 5			Envelopes (9x12) x box	
Tape: Speed tape x 1			Falling Ball Viscometer + Syringes	
Tape measurer (large yellow + small)			File box x 2	
Temperature probes: immersion x 3			Hard drive (if necessary)	
Temperature probes: surface x 3			iPads x 1	
Test plate covers (white plastic) x 15			Laptop for Rate Station and smart buttons	
Test plate covers (wooden boards) x 12			Mouse for Rate Station and keypad	
Test Plates: Composite Full Plates x 8			Paper for printer x 1 pack	
Test Plates: Half plates x 20 (40 halves) w/buttons			Pencils + pens + markers	
Test Plates: Full plates x 24 w/buttons			Scissors	
Test Stand Collection Pans (one per stand)			Test Procedures x 6, printer paper	
Test Stand Shims (poker chips) x 1 box			Walkie Talkies and Accessories x 12	
Test Stands: 2 x Short 6-position (main stand)			Waterproof paper (40 sheets)	
Test Stands: 2 x Short 6-position (side stand)			YOW employee contracts	
Thickness Gauges: 4 rectangles				
Thickness Gauges: 4 octagons				
Tuques x 10				
Vise grip (large) + rubber opener				
Water (3 x 18L) for hard water				
Whatman paper kit + dye				
White poster board panels for water run-off				

9. PRE-TESTING AND TESTING ACTIVITIES

Table 9.1 demonstrates the activities that will be completed prior to arriving at the NRC.

Table 9.1: Task List for Setup and Actual Tests

No.	Task	Person	Status
	Planning and Preparation		
1	Co-ordinate with NRC personnel and check status of chamber	MR	
2	Ensure fluid is received and ready to be transported to NRC	PK	
3	Arrange for hotel accommodations for APS personnel	JS	
4	Arrange truck rental	JS	
5	Arrange for ice delivery	JS	
6	Order walkie talkies	JS	
7	Organize personnel travel to Ottawa;	MR	
8	Hire YOW personnel	MR/FDL	
9	Complete contract for YOW personnel	FDL	
10	Co-ordinate with APS photographer	MR	
11	Prepare and Arrange Office Materials for YOW	PK	
12	Prepare Data forms and procedure	PK	
13	Prepare Test Log	PK	
14	Update (as necessary) fluid viscosity log, and have available viscosity of fluids	PK	
15	Finalize and complete list of equipment/materials required	PK/ALL	
16	Prepare and Arrange Site Equipment for YOW	PK/SM	
17	Ensure proper functioning of snow dispenser equipment;	MR	
18	Prepare fluid pouring containers	SM/PK	
19	Review SN dispersal techniques and location	DL/BB/MR	
20	Update SN Order Form (if necessary)	DL/BB/MR/PK	
21	Complete purchase list and shopping	PK	
22	Pack and leave YUL for YOW	APS	
23	Mark plates with plate numbers on back and front – marking should be at bottom	SM	
24	Calibrate snow dispensers for the NRC set-up	DL/SM	
25	Conduct fluid variability calibration for simulated snow	DL/SM	
26	Rate pans: check quantity, check properly labelled, and verify spares available	PK/SM	
27	Equip plates with operational and verified thermistors or SmartButtons	SM/BB	
28	Prepare coded labels for pour containers as per fluids list	PK	
29	Check laptops (2) work for rate station	BB	
30	Review "NRC Rate Station 101"	BB	
31	Confirm NRC availability of camera system + black shelving unit	MR/JD	
32	Confirm NRC Setup Waste tote + floor mats in chamber for setup day	STB	
33	Confirm NRC availability of Rate monitoring system	MR/JD	
34	Confirm NRC that the freezer works and is ON the day before testing	MR/JD	
35	Confirm NRC will set up test area temperature sensors for morning of test	MR/JD	
36	Confirm NRC will have hallways and chamber are free of clutter	MR/JD	
37	Arrange special video camera equipment for monitoring and recording tests	SM	
	Setup Day		
38	General safety briefing and update on testing	APS/NRC/YOW	
39	Unload Truck and organize equipment	APS	
40	Verify and Organize Fluid	PK/SM	
41	Confirm ice delivery	BB	
42	Setup general office and testing equipment, confirm printer and projector available	PK	
43	Setup rate station	BB	
44	Setup SN manufacturing material in Cold Chamber	STB	
45	Test and prepare SN dispensing equipment	STB	
46	Coordinate fabrication of snow	PK/STB	
47	Setup Still and Video Cameras	SM/SN	
48	Verify photo and video requirements	SN/MR	
	Testing Day 1		
49	SN and ZF Calibration	All	
50	Train SN making personnel (ongoing) and continue SN manufacturing	STB/YOW	
51	Start Testing	APS/NRC	
	Each Testing Day		
52	Deicide personnel requirements for following day for 24hr notice	MR	
53	Prepare equipment and fluid to be used for test	BB	
54	Manufacture snow	STB/YOW	
55	Prepare photography equipment	SN	
56	Prepare data forms for test	PK	
57	Conduct tests based on test plan	APS	
58	Modify test plan based on results obtained	TC/FAA/JD/MR	
59	Update snow, raw ice, and fluid inventory (end of day)	PK/YOW	
60	Update fluid inventory (2 container left warning)	BB/STB	
61	Update test log and test plan (ongoing and end of day)	PK/MR	

Figure 9.1 provides and overview of the expected activities on the first three days of testing at the NRC.

<table>
<tr><th></th><th colspan="4">MONDAY</th><th></th><th colspan="4">Tuesday
(Climatic Chamber Temperature: -3°C)</th><th></th><th colspan="3">Wednesday
(Climatic Chamber Temperature: -3°C)</th></tr>
<tr><td>8:00</td><td colspan="4" rowspan="6">All: Travel to NRC from YUL</td><td rowspan="12"></td><td rowspan="12">Project Manager (MR)</td><td rowspan="6">Rate Support / Documentation / Snow Order + Dispensing Manager (PK)</td><td rowspan="6">Rate Station Manager (BB/DL)</td><td rowspan="12">Remote Cameras - Support & Fine Tuning (SM/SN)</td><td rowspan="12"></td><td rowspan="12">Project Manager (MR)</td><td rowspan="12">Test Documentation / Snow Order + Dispensing Manager (PK)</td><td rowspan="12">Stand Manager / Fluid Manager / Rates (BB/DL)</td></tr>
<tr><td>8:30</td></tr>
<tr><td>9:00</td></tr>
<tr><td>9:30</td></tr>
<tr><td>10:00</td></tr>
<tr><td>10:30</td></tr>
<tr><td>11:00</td><td colspan="4">All: Meet, greet, safety brief</td></tr>
<tr><td>11:30</td><td colspan="4" rowspan="2">All: Un-pack</td></tr>
<tr><td>12:00</td></tr>
<tr><td>12:30</td><td rowspan="3">Ice Delivery (YOW/MR)</td><td rowspan="3">Setup Office Stations (PK & MR)</td><td rowspan="3">SN Setup, Training, and Production (BB/DL)</td><td rowspan="6">Setup Remote Cameras (SM/SN)</td><td rowspan="6">Test Documentation / Snow Order + Dispensing Manager (PK)</td><td rowspan="6">Stand Manager / Fluid Manager (BB/DL)</td></tr>
<tr><td>13:00</td></tr>
<tr><td>13:30</td></tr>
<tr><td>14:00</td><td rowspan="4">Snow Production (YOW/MR)</td><td rowspan="3">Fluids, Labeling, Preparation (PK)</td><td rowspan="3">Stand Setup (BB/DL)</td></tr>
<tr><td>14:30</td></tr>
<tr><td>15:00</td></tr>
<tr><td>15:30</td><td>Verify Plate SmartButtons (PK)</td><td>Dispenser Setup (BB/DL)</td></tr>
<tr><td>16:00</td></tr>
</table>

Figure 9.1: Coordination Plan for First 3 Days of Testing

10. SAFETY

Managers of the project must ensure that personnel involved in the set-up and conduct of their respective projects are aware of the following:

1. A safety briefing will be done on the first day of testing;
2. COVID-19 mitigation procedures will be in place;
3. Fluid SDS sheets are available for review;
4. CSA approved footwear and appropriate clothing for frigid temperatures are to be worn by all personnel;
5. Waterproof clothing and gloves are available;
6. Fluid(s) should only be handled with protective gloves. If any fluid gets onto the skin, wash the effected area thoroughly;
7. Rubber mats must be properly placed in and around the test area and cleaned as necessary;
8. Care should be taken when circulating near the test stand due to slipperiness;

9. First aid kit, water and fire extinguisher are available; and
10. All NRC safety guidelines must be followed.

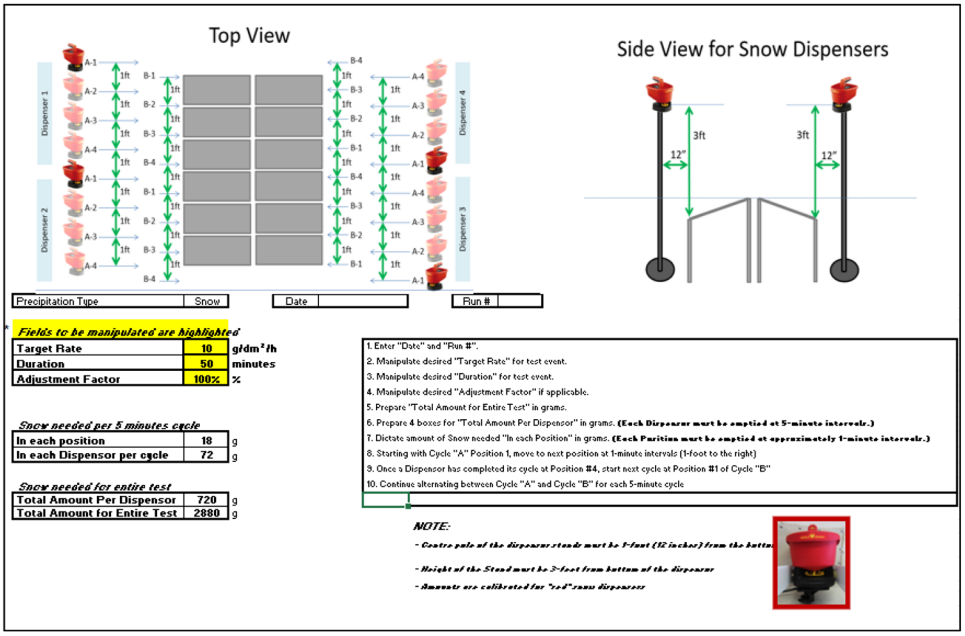
Separate guidelines related to COVID-19 mitigation strategies will be communicated to staff prior to the start of any activities.

Personnel must operate in accordance with the "Testing Safety Recommendations" and must follow the protocols for "Extended Work Hours Protocol for APS Personnel." These documents are included in the "APS Office Policies & Procedures," which is made available to all APS staff.

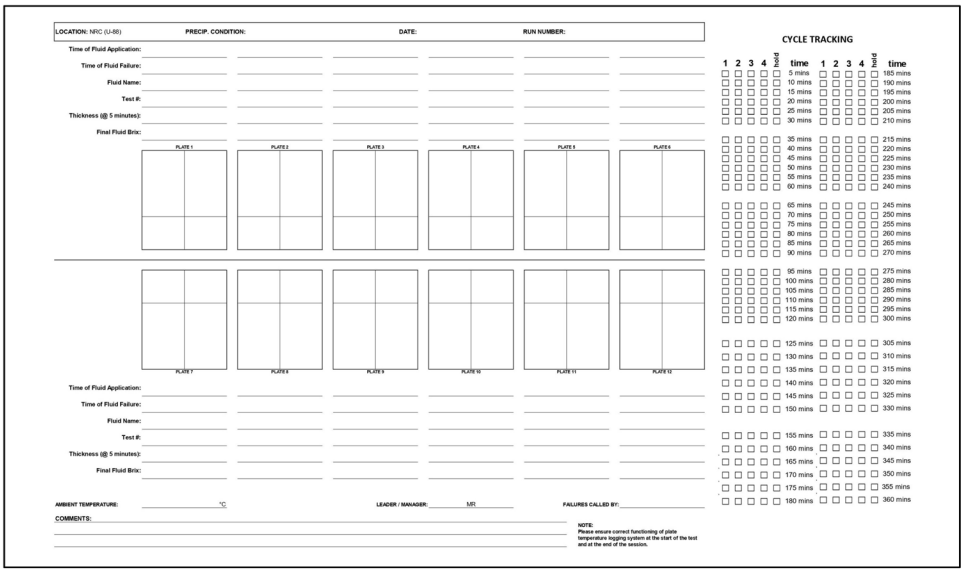
11. DATA FORMS

An endurance time testing form to be used for all tests is included in Attachment 2. An additional snow dispensing form for calculating snow quantities required for each test is included in the data form used to record the endurance time for any of the conditions being completed is shown in Attachment 1.

Attachment 1: Example of Snow Dispensing Form



Attachment 2: Example of Endurance Time Data Form



Attachment 3: Proposed Test Plan for Testing Snow Mixed with Freezing Fog

Test No.	Priority	Test Type	Fluid	Dilution	APS Fluid Code	Fluid Type	Precipitation	Test Surface	Test Temp. (°C)	Fluid Temp. (°C)	Snow Rate (g/dm²/h)	Freezing Fog Rate (g/dm²/h)
1	1	Duplicate	PG ADF Concentrate	33/67	097A	I	Freezing Fog	Aluminum	-3	20°C	-	5
2	1	Duplicate	PG ADF Concentrate	33/67	097A	I	Freezing Fog	Aluminum	-3	20°C	-	5
3	1	Quadruplet	PG ADF Concentrate	33/67	097A	I	Freezing Fog	Aluminum	-3	20°C	-	5
4	1	Quadruplet	PG ADF Concentrate	33/67	097A	I	Freezing Fog	Aluminum	-3	20°C	-	5
5	1	Octuplet	PG ADF Concentrate	33/67	097A	I	Freezing Fog	Aluminum	-3	20°C	-	5
6	1	Octuplet	PG ADF Concentrate	33/67	097A	I	Freezing Fog	Aluminum	-3	20°C	-	5
7	1	Octuplet	PG ADF Concentrate	33/67	097A	I	Freezing Fog	Aluminum	-3	20°C	-	5
8	1	Octuplet	PG ADF Concentrate	33/67	097A	I	Freezing Fog	Aluminum	-3	20°C	-	5
9	1	Duplicate	PG ADF Concentrate	33/67	097A	I	Freezing Fog	Composite	-3	20°C	-	5
10	1	Duplicate	PG ADF Concentrate	33/67	097A	I	Freezing Fog	Composite	-3	20°C	-	5
11	1	Quadruplet	PG ADF Concentrate	33/67	097A	I	Freezing Fog	Composite	-3	20°C	-	5
12	1	Quadruplet	PG ADF Concentrate	33/67	097A	I	Freezing Fog	Composite	-3	20°C	-	5
13	1	Octuplet	PG ADF Concentrate	33/67	097A	I	Freezing Fog	Composite	-3	20°C	-	5
14	1	Octuplet	PG ADF Concentrate	33/67	097A	I	Freezing Fog	Composite	-3	20°C	-	5
15	1	Octuplet	PG ADF Concentrate	33/67	097A	I	Freezing Fog	Composite	-3	20°C	-	5
16	1	Octuplet	PG ADF Concentrate	33/67	097A	I	Freezing Fog	Composite	-3	20°C	-	5
17	1	Duplicate	Safewing MP II FLIGHT	100/0	023A	II	Freezing Fog	Aluminum	-3	OAT	-	5
18	1	Duplicate	Safewing MP II FLIGHT	100/0	023A	II	Freezing Fog	Aluminum	-3	OAT	-	5
19	1	Quadruplet	Safewing MP II FLIGHT	100/0	023A	II	Freezing Fog	Aluminum	-3	OAT	-	5
20	1	Quadruplet	Safewing MP II FLIGHT	100/0	023A	II	Freezing Fog	Aluminum	-3	OAT	-	5
21	1	Octuplet	Safewing MP II FLIGHT	100/0	023A	II	Freezing Fog	Aluminum	-3	OAT	-	5
22	1	Octuplet	Safewing MP II FLIGHT	100/0	023A	II	Freezing Fog	Aluminum	-3	OAT	-	5
23	1	Octuplet	Safewing MP II FLIGHT	100/0	023A	II	Freezing Fog	Aluminum	-3	OAT	-	5
24	1	Octuplet	Safewing MP II FLIGHT	100/0	023A	II	Freezing Fog	Aluminum	-3	OAT	-	5
25	1	Calibration	AeroClear MAX	100/0	063A	III	Freezing Fog	Aluminum	-3	OAT	-	5
26	1	Calibration	AeroClear MAX	100/0	063A	III	Freezing Fog	Aluminum	-3	OAT	-	5
27	1	Calibration	AeroClear MAX	100/0	063A	III	Freezing Fog	Aluminum	-3	OAT	-	5
28	1	Calibration	AeroClear MAX	100/0	063A	III	Freezing Fog	Aluminum	-3	OAT	-	5
29	1	Calibration	AeroClear MAX	100/0	063A	III	Freezing Fog	Aluminum	-3	OAT	-	5
30	1	Calibration	AeroClear MAX	100/0	063A	III	Freezing Fog	Aluminum	-3	OAT	-	5
31	1	Calibration	AeroClear MAX	100/0	063A	III	Freezing Fog	Aluminum	-3	OAT	-	5

Attachment 3: Proposed Test Plan for Testing Snow Mixed with Freezing Fog (cont'd)

Test No.	Priority	Test Type	Fluid	Dilution	APS Fluid Code	Fluid Type	Precipitation	Test Surface	Test Temp. (°C)	Fluid Temp. (°C)	Snow Rate (g/dm²/h)	Freezing Fog Rate (g/dm²/h)
32	1	Calibration	AeroClear MAX	100/0	063A	III	Freezing Fog	Aluminum	-3	OAT	-	5
33	1	Calibration	AeroClear MAX	100/0	063A	III	Freezing Fog	Aluminum	-3	OAT	-	5
34	1	Calibration	AeroClear MAX	100/0	063A	III	Freezing Fog	Aluminum	-3	OAT	-	5
35	1	Calibration	AeroClear MAX	100/0	063A	III	Freezing Fog	Aluminum	-3	OAT	-	5
36	1	Calibration	AeroClear MAX	100/0	063A	III	Freezing Fog	Aluminum	-3	OAT	-	5
37	1	Duplicate	Polar Guard Advance	100/0	090A	IV	Freezing Fog	Aluminum	-3	OAT	-	5
38	1	Duplicate	Polar Guard Advance	100/0	090A	IV	Freezing Fog	Aluminum	-3	OAT	-	5
39	1	Quadruplet	Polar Guard Advance	100/0	090A	IV	Freezing Fog	Aluminum	-3	OAT	-	5
40	1	Quadruplet	Polar Guard Advance	100/0	090A	IV	Freezing Fog	Aluminum	-3	OAT	-	5
41	1	Octuplet	Polar Guard Advance	100/0	090A	IV	Freezing Fog	Aluminum	-3	OAT	-	5
42	1	Octuplet	Polar Guard Advance	100/0	090A	IV	Freezing Fog	Aluminum	-3	OAT	-	5
43	1	Octuplet	Polar Guard Advance	100/0	090A	IV	Freezing Fog	Aluminum	-3	OAT	-	5
44	1	Octuplet	Polar Guard Advance	100/0	090A	IV	Freezing Fog	Aluminum	-3	OAT	-	5
45	1	Duplicate	EG106	100/0	096A	IV	Freezing Fog	Aluminum	-3	OAT	-	5
46	1	Duplicate	EG106	100/0	096A	IV	Freezing Fog	Aluminum	-3	OAT	-	5
47	1	Quadruplet	EG106	100/0	096A	IV	Freezing Fog	Aluminum	-3	OAT	-	5
48	1	Quadruplet	EG106	100/0	096A	IV	Freezing Fog	Aluminum	-3	OAT	-	5
49	1	Octuplet	EG106	100/0	096A	IV	Freezing Fog	Aluminum	-3	OAT	-	5
50	1	Octuplet	EG106	100/0	096A	IV	Freezing Fog	Aluminum	-3	OAT	-	5
51	1	Octuplet	EG106	100/0	096A	IV	Freezing Fog	Aluminum	-3	OAT	-	5
52	1	Octuplet	EG106	100/0	096A	IV	Freezing Fog	Aluminum	-3	OAT	-	5
53	1	Duplicate	PG ADF Concentrate	46/54	097A	I	Freezing Fog	Aluminum	-14	20°C	-	5
54	1	Duplicate	PG ADF Concentrate	46/54	097A	I	Freezing Fog	Aluminum	-14	20°C	-	5
55	1	Quadruplet	PG ADF Concentrate	46/54	097A	I	Freezing Fog	Aluminum	-14	20°C	-	5
56	1	Quadruplet	PG ADF Concentrate	46/54	097A	I	Freezing Fog	Aluminum	-14	20°C	-	5
57	1	Octuplet	PG ADF Concentrate	46/54	097A	I	Freezing Fog	Aluminum	-14	20°C	-	5
58	1	Octuplet	PG ADF Concentrate	46/54	097A	I	Freezing Fog	Aluminum	-14	20°C	-	5
59	1	Octuplet	PG ADF Concentrate	46/54	097A	I	Freezing Fog	Aluminum	-14	20°C	-	5
60	1	Octuplet	PG ADF Concentrate	46/54	097A	I	Freezing Fog	Aluminum	-14	20°C	-	5
61	1	Duplicate	PG ADF Concentrate	46/54	097A	I	Freezing Fog	Composite	-14	20°C	-	5
62	1	Duplicate	PG ADF Concentrate	46/54	097A	I	Freezing Fog	Composite	-14	20°C	-	5
63	1	Quadruplet	PG ADF Concentrate	46/54	097A	I	Freezing Fog	Composite	-14	20°C	-	5

Attachment 3: Proposed Test Plan for Testing Snow Mixed with Freezing Fog (cont'd)

Test No.	Priority	Test Type	Fluid	Dilution	APS Fluid Code	Fluid Type	Precipitation	Test Surface	Test Temp. (°C)	Fluid Temp. (°C)	Snow Rate (g/dm²/h)	Freezing Fog Rate (g/dm²/h)
64	1	Quadruplet	PG ADF Concentrate	46/54	097A	I	Freezing Fog	Composite	-14	20°C	-	5
65	1	Octuplet	PG ADF Concentrate	46/54	097A	I	Freezing Fog	Composite	-14	20°C	-	5
66	1	Octuplet	PG ADF Concentrate	46/54	097A	I	Freezing Fog	Composite	-14	20°C	-	5
67	1	Octuplet	PG ADF Concentrate	46/54	097A	I	Freezing Fog	Composite	-14	20°C	-	5
68	1	Octuplet	PG ADF Concentrate	46/54	097A	I	Freezing Fog	Composite	-14	20°C	-	5
69	1	Duplicate	Safewing MP II FLIGHT	100/0	023A	II	Freezing Fog	Aluminum	-14	OAT	-	5
70	1	Duplicate	Safewing MP II FLIGHT	100/0	023A	II	Freezing Fog	Aluminum	-14	OAT	-	5
71	1	Quadruplet	Safewing MP II FLIGHT	100/0	023A	II	Freezing Fog	Aluminum	-14	OAT	-	5
72	1	Quadruplet	Safewing MP II FLIGHT	100/0	023A	II	Freezing Fog	Aluminum	-14	OAT	-	5
73	1	Octuplet	Safewing MP II FLIGHT	100/0	023A	II	Freezing Fog	Aluminum	-14	OAT	-	5
74	1	Octuplet	Safewing MP II FLIGHT	100/0	023A	II	Freezing Fog	Aluminum	-14	OAT	-	5
75	1	Octuplet	Safewing MP II FLIGHT	100/0	023A	II	Freezing Fog	Aluminum	-14	OAT	-	5
76	1	Octuplet	Safewing MP II FLIGHT	100/0	023A	II	Freezing Fog	Aluminum	-14	OAT	-	5
77	1	Duplicate	AeroClear MAX	100/0	067A	III	Freezing Fog	Aluminum	-14	OAT	-	5
78	1	Duplicate	AeroClear MAX	100/0	067A	III	Freezing Fog	Aluminum	-14	OAT	-	5
79	1	Quadruplet	AeroClear MAX	100/0	067A	III	Freezing Fog	Aluminum	-14	OAT	-	5
80	1	Quadruplet	AeroClear MAX	100/0	067A	III	Freezing Fog	Aluminum	-14	OAT	-	5
81	1	Octuplet	AeroClear MAX	100/0	067A	III	Freezing Fog	Aluminum	-14	OAT	-	5
82	1	Octuplet	AeroClear MAX	100/0	067A	III	Freezing Fog	Aluminum	-14	OAT	-	5
83	1	Octuplet	AeroClear MAX	100/0	067A	III	Freezing Fog	Aluminum	-14	OAT	-	5
84	1	Octuplet	AeroClear MAX	100/0	067A	III	Freezing Fog	Aluminum	-14	OAT	-	5
85	1	Duplicate	Polar Guard Advance	100/0	090A	IV	Freezing Fog	Aluminum	-14	OAT	-	5
86	1	Duplicate	Polar Guard Advance	100/0	090A	IV	Freezing Fog	Aluminum	-14	OAT	-	5
87	1	Quadruplet	Polar Guard Advance	100/0	090A	IV	Freezing Fog	Aluminum	-14	OAT	-	5
88	1	Quadruplet	Polar Guard Advance	100/0	090A	IV	Freezing Fog	Aluminum	-14	OAT	-	5
89	1	Octuplet	Polar Guard Advance	100/0	090A	IV	Freezing Fog	Aluminum	-14	OAT	-	5
90	1	Octuplet	Polar Guard Advance	100/0	090A	IV	Freezing Fog	Aluminum	-14	OAT	-	5
91	1	Octuplet	Polar Guard Advance	100/0	090A	IV	Freezing Fog	Aluminum	-14	OAT	-	5
92	1	Octuplet	Polar Guard Advance	100/0	090A	IV	Freezing Fog	Aluminum	-14	OAT	-	5
93	1	Duplicate	EG106	100/0	096A	IV	Freezing Fog	Aluminum	-14	OAT	-	5
94	1	Duplicate	EG106	100/0	096A	IV	Freezing Fog	Aluminum	-14	OAT	-	5
95	1	Quadruplet	EG106	100/0	096A	IV	Freezing Fog	Aluminum	-14	OAT	-	5

Attachment 3: Proposed Test Plan for Testing Snow Mixed with Freezing Fog (cont'd)

Test No.	Priority	Test Type	Fluid	Dilution	APS Fluid Code	Fluid Type	Precipitation	Test Surface	Test Temp. (°C)	Fluid Temp. (°C)	Snow Rate (g/dm²/h)	Freezing Fog Rate (g/dm²/h)
96	1	Quadruplet	EG106	100/0	096A	IV	Freezing Fog	Aluminum	-14	OAT	-	5
97	1	Octuplet	EG106	100/0	096A	IV	Freezing Fog	Aluminum	-14	OAT	-	5
98	1	Octuplet	EG106	100/0	096A	IV	Freezing Fog	Aluminum	-14	OAT	-	5
99	1	Octuplet	EG106	100/0	096A	IV	Freezing Fog	Aluminum	-14	OAT	-	5
100	1	Octuplet	EG106	100/0	096A	IV	Freezing Fog	Aluminum	-14	OAT	-	5
101	2	Duplicate	PG ADF Concentrate	55/45	097A	I	Freezing Fog	Aluminum	-25	20°C	-	5
102	2	Duplicate	PG ADF Concentrate	55/45	097A	I	Freezing Fog	Aluminum	-25	20°C	-	5
103	2	Quadruplet	PG ADF Concentrate	55/45	097A	I	Freezing Fog	Aluminum	-25	20°C	-	5
104	2	Quadruplet	PG ADF Concentrate	55/45	097A	I	Freezing Fog	Aluminum	-25	20°C	-	5
105	2	Octuplet	PG ADF Concentrate	55/45	097A	I	Freezing Fog	Aluminum	-25	20°C	-	5
106	2	Octuplet	PG ADF Concentrate	55/45	097A	I	Freezing Fog	Aluminum	-25	20°C	-	5
107	2	Octuplet	PG ADF Concentrate	55/45	097A	I	Freezing Fog	Aluminum	-25	20°C	-	5
108	2	Octuplet	PG ADF Concentrate	55/45	097A	I	Freezing Fog	Aluminum	-25	20°C	-	5
109	2	Duplicate	PG ADF Concentrate	55/45	097A	I	Freezing Fog	Composite	-25	20°C	-	5
110	2	Duplicate	PG ADF Concentrate	55/45	097A	I	Freezing Fog	Composite	-25	20°C	-	5
111	2	Quadruplet	PG ADF Concentrate	55/45	097A	I	Freezing Fog	Composite	-25	20°C	-	5
112	2	Quadruplet	PG ADF Concentrate	55/45	097A	I	Freezing Fog	Composite	-25	20°C	-	5
113	2	Octuplet	PG ADF Concentrate	55/45	097A	I	Freezing Fog	Composite	-25	20°C	-	5
114	2	Octuplet	PG ADF Concentrate	55/45	097A	I	Freezing Fog	Composite	-25	20°C	-	5
115	2	Octuplet	PG ADF Concentrate	55/45	097A	I	Freezing Fog	Composite	-25	20°C	-	5
116	2	Octuplet	PG ADF Concentrate	55/45	097A	I	Freezing Fog	Composite	-25	20°C	-	5
117	2	Duplicate	Safewing MP II FLIGHT	100/0	023A	II	Freezing Fog	Aluminum	-25	OAT	-	5
118	2	Duplicate	Safewing MP II FLIGHT	100/0	023A	II	Freezing Fog	Aluminum	-25	OAT	-	5
119	2	Quadruplet	Safewing MP II FLIGHT	100/0	023A	II	Freezing Fog	Aluminum	-25	OAT	-	5
120	2	Quadruplet	Safewing MP II FLIGHT	100/0	023A	II	Freezing Fog	Aluminum	-25	OAT	-	5
121	2	Octuplet	Safewing MP II FLIGHT	100/0	023A	II	Freezing Fog	Aluminum	-25	OAT	-	5
122	2	Octuplet	Safewing MP II FLIGHT	100/0	023A	II	Freezing Fog	Aluminum	-25	OAT	-	5
123	2	Octuplet	Safewing MP II FLIGHT	100/0	023A	II	Freezing Fog	Aluminum	-25	OAT	-	5
124	2	Octuplet	Safewing MP II FLIGHT	100/0	023A	II	Freezing Fog	Aluminum	-25	OAT	-	5
125	2	Duplicate	AeroClear MAX	100/0	067A	III	Freezing Fog	Aluminum	-25	OAT	-	5
126	2	Duplicate	AeroClear MAX	100/0	067A	III	Freezing Fog	Aluminum	-25	OAT	-	5
127	2	Quadruplet	AeroClear MAX	100/0	067A	III	Freezing Fog	Aluminum	-25	OAT	-	5

Attachment 3: Proposed Test Plan for Testing Snow Mixed with Freezing Fog (cont'd)

Test No.	Priority	Test Type	Fluid	Dilution	APS Fluid Code	Fluid Type	Precipitation	Test Surface	Test Temp. (°C)	Fluid Temp. (°C)	Snow Rate (g/dm²/h)	Freezing Fog Rate (g/dm²/h)
128	2	Quadruplet	AeroClear MAX	100/0	067A	III	Freezing Fog	Aluminum	-25	OAT	-	5
129	2	Octuplet	AeroClear MAX	100/0	067A	III	Freezing Fog	Aluminum	-25	OAT	-	5
130	2	Octuplet	AeroClear MAX	100/0	067A	III	Freezing Fog	Aluminum	-25	OAT	-	5
131	2	Octuplet	AeroClear MAX	100/0	067A	III	Freezing Fog	Aluminum	-25	OAT	-	5
132	2	Octuplet	AeroClear MAX	100/0	067A	III	Freezing Fog	Aluminum	-25	OAT	-	5
133	2	Duplicate	Polar Guard Advance	100/0	090A	IV	Freezing Fog	Aluminum	-25	OAT	-	5
134	2	Duplicate	Polar Guard Advance	100/0	090A	IV	Freezing Fog	Aluminum	-25	OAT	-	5
135	2	Quadruplet	Polar Guard Advance	100/0	090A	IV	Freezing Fog	Aluminum	-25	OAT	-	5
136	2	Quadruplet	Polar Guard Advance	100/0	090A	IV	Freezing Fog	Aluminum	-25	OAT	-	5
137	2	Octuplet	Polar Guard Advance	100/0	090A	IV	Freezing Fog	Aluminum	-25	OAT	-	5
138	2	Octuplet	Polar Guard Advance	100/0	090A	IV	Freezing Fog	Aluminum	-25	OAT	-	5
139	2	Octuplet	Polar Guard Advance	100/0	090A	IV	Freezing Fog	Aluminum	-25	OAT	-	5
140	2	Octuplet	Polar Guard Advance	100/0	090A	IV	Freezing Fog	Aluminum	-25	OAT	-	5
141	2	Duplicate	EG106	100/0	096A	IV	Freezing Fog	Aluminum	-25	OAT	-	5
142	2	Duplicate	EG106	100/0	096A	IV	Freezing Fog	Aluminum	-25	OAT	-	5
143	2	Quadruplet	EG106	100/0	096A	IV	Freezing Fog	Aluminum	-25	OAT	-	5
144	2	Quadruplet	EG106	100/0	096A	IV	Freezing Fog	Aluminum	-25	OAT	-	5
145	2	Octuplet	EG106	100/0	096A	IV	Freezing Fog	Aluminum	-25	OAT	-	5
146	2	Octuplet	EG106	100/0	096A	IV	Freezing Fog	Aluminum	-25	OAT	-	5
147	2	Octuplet	EG106	100/0	096A	IV	Freezing Fog	Aluminum	-25	OAT	-	5
148	2	Octuplet	EG106	100/0	096A	IV	Freezing Fog	Aluminum	-25	OAT	-	5
149	1	Duplicate	PG ADF Concentrate	33/67	097A	I	Light Snow	Aluminum	-3	20°C	10	-
150	1	Duplicate	PG ADF Concentrate	33/67	097A	I	Light Snow	Aluminum	-3	20°C	10	-
151	1	Quadruplet	PG ADF Concentrate	33/67	097A	I	Light Snow	Aluminum	-3	20°C	10	-
152	1	Quadruplet	PG ADF Concentrate	33/67	097A	I	Light Snow	Aluminum	-3	20°C	10	-
153	1	Octuplet	PG ADF Concentrate	33/67	097A	I	Light Snow	Aluminum	-3	20°C	10	-
154	1	Octuplet	PG ADF Concentrate	33/67	097A	I	Light Snow	Aluminum	-3	20°C	10	-
155	1	Octuplet	PG ADF Concentrate	33/67	097A	I	Light Snow	Aluminum	-3	20°C	10	-
156	1	Octuplet	PG ADF Concentrate	33/67	097A	I	Light Snow	Aluminum	-3	20°C	10	-
157	1	Duplicate	PG ADF Concentrate	33/67	097A	I	Light Snow	Composite	-3	20°C	10	-
158	1	Duplicate	PG ADF Concentrate	33/67	097A	I	Light Snow	Composite	-3	20°C	10	-
159	1	Quadruplet	PG ADF Concentrate	33/67	097A	I	Light Snow	Composite	-3	20°C	10	-

Attachment 3: Proposed Test Plan for Testing Snow Mixed with Freezing Fog (cont'd)

Test No.	Priority	Test Type	Fluid	Dilution	APS Fluid Code	Fluid Type	Precipitation	Test Surface	Test Temp. (°C)	Fluid Temp. (°C)	Snow Rate (g/dm²/h)	Freezing Fog Rate (g/dm²/h)
160	1	Quadruplet	PG ADF Concentrate	33/67	097A	I	Light Snow	Composite	-3	20°C	10	-
161	1	Octuplet	PG ADF Concentrate	33/67	097A	I	Light Snow	Composite	-3	20°C	10	-
162	1	Octuplet	PG ADF Concentrate	33/67	097A	I	Light Snow	Composite	-3	20°C	10	-
163	1	Octuplet	PG ADF Concentrate	33/67	097A	I	Light Snow	Composite	-3	20°C	10	-
164	1	Octuplet	PG ADF Concentrate	33/67	097A	I	Light Snow	Composite	-3	20°C	10	-
165	1	Duplicate	Safewing MP II FLIGHT	100/0	023A	II	Light Snow	Aluminum	-3	OAT	10	-
166	1	Duplicate	Safewing MP II FLIGHT	100/0	023A	II	Light Snow	Aluminum	-3	OAT	10	-
167	1	Quadruplet	Safewing MP II FLIGHT	100/0	023A	II	Light Snow	Aluminum	-3	OAT	10	-
168	1	Quadruplet	Safewing MP II FLIGHT	100/0	023A	II	Light Snow	Aluminum	-3	OAT	10	-
169	1	Octuplet	Safewing MP II FLIGHT	100/0	023A	II	Light Snow	Aluminum	-3	OAT	10	-
170	1	Octuplet	Safewing MP II FLIGHT	100/0	023A	II	Light Snow	Aluminum	-3	OAT	10	-
171	1	Octuplet	Safewing MP II FLIGHT	100/0	023A	II	Light Snow	Aluminum	-3	OAT	10	-
172	1	Octuplet	Safewing MP II FLIGHT	100/0	023A	II	Light Snow	Aluminum	-3	OAT	10	-
173	1	Calibration	AeroClear MAX	100/0	063A	III	Light Snow	Aluminum	-3	OAT	10	-
174	1	Calibration	AeroClear MAX	100/0	063A	III	Light Snow	Aluminum	-3	OAT	10	-
175	1	Calibration	AeroClear MAX	100/0	063A	III	Light Snow	Aluminum	-3	OAT	10	-
176	1	Calibration	AeroClear MAX	100/0	063A	III	Light Snow	Aluminum	-3	OAT	10	-
177	1	Calibration	AeroClear MAX	100/0	063A	III	Light Snow	Aluminum	-3	OAT	10	-
178	1	Calibration	AeroClear MAX	100/0	063A	III	Light Snow	Aluminum	-3	OAT	10	-
179	1	Calibration	AeroClear MAX	100/0	063A	III	Light Snow	Aluminum	-3	OAT	10	-
180	1	Calibration	AeroClear MAX	100/0	063A	III	Light Snow	Aluminum	-3	OAT	10	-
181	1	Calibration	AeroClear MAX	100/0	063A	III	Light Snow	Aluminum	-3	OAT	10	-
182	1	Calibration	AeroClear MAX	100/0	063A	III	Light Snow	Aluminum	-3	OAT	10	-
183	1	Calibration	AeroClear MAX	100/0	063A	III	Light Snow	Aluminum	-3	OAT	10	-
184	1	Calibration	AeroClear MAX	100/0	063A	III	Light Snow	Aluminum	-3	OAT	10	-
185	1	Duplicate	Polar Guard Advance	100/0	090A	IV	Light Snow	Aluminum	-3	OAT	10	-
186	1	Duplicate	Polar Guard Advance	100/0	090A	IV	Light Snow	Aluminum	-3	OAT	10	-
187	1	Quadruplet	Polar Guard Advance	100/0	090A	IV	Light Snow	Aluminum	-3	OAT	10	-
188	1	Quadruplet	Polar Guard Advance	100/0	090A	IV	Light Snow	Aluminum	-3	OAT	10	-
189	1	Octuplet	Polar Guard Advance	100/0	090A	IV	Light Snow	Aluminum	-3	OAT	10	-
190	1	Octuplet	Polar Guard Advance	100/0	090A	IV	Light Snow	Aluminum	-3	OAT	10	-
191	1	Octuplet	Polar Guard Advance	100/0	090A	IV	Light Snow	Aluminum	-3	OAT	10	-

Attachment 3: Proposed Test Plan for Testing Snow Mixed with Freezing Fog (cont'd)

Test No.	Priority	Test Type	Fluid	Dilution	APS Fluid Code	Fluid Type	Precipitation	Test Surface	Test Temp. (°C)	Fluid Temp. (°C)	Snow Rate (g/dm²/h)	Freezing Fog Rate (g/dm²/h)
192	1	Octuplet	Polar Guard Advance	100/0	090A	IV	Light Snow	Aluminum	-3	OAT	10	-
193	1	Duplicate	EG106	100/0	096A	IV	Light Snow	Aluminum	-3	OAT	10	-
194	1	Duplicate	EG106	100/0	096A	IV	Light Snow	Aluminum	-3	OAT	10	-
195	1	Quadruplet	EG106	100/0	096A	IV	Light Snow	Aluminum	-3	OAT	10	-
196	1	Quadruplet	EG106	100/0	096A	IV	Light Snow	Aluminum	-3	OAT	10	-
197	1	Octuplet	EG106	100/0	096A	IV	Light Snow	Aluminum	-3	OAT	10	-
198	1	Octuplet	EG106	100/0	096A	IV	Light Snow	Aluminum	-3	OAT	10	-
199	1	Octuplet	EG106	100/0	096A	IV	Light Snow	Aluminum	-3	OAT	10	-
200	1	Octuplet	EG106	100/0	096A	IV	Light Snow	Aluminum	-3	OAT	10	-
201	1	Duplicate	PG ADF Concentrate	33/67	097A	I	Moderate Snow	Aluminum	-3	20°C	25	-
202	1	Duplicate	PG ADF Concentrate	33/67	097A	I	Moderate Snow	Aluminum	-3	20°C	25	-
203	1	Quadruplet	PG ADF Concentrate	33/67	097A	I	Moderate Snow	Aluminum	-3	20°C	25	-
204	1	Quadruplet	PG ADF Concentrate	33/67	097A	I	Moderate Snow	Aluminum	-3	20°C	25	-
205	1	Octuplet	PG ADF Concentrate	33/67	097A	I	Moderate Snow	Aluminum	-3	20°C	25	-
206	1	Octuplet	PG ADF Concentrate	33/67	097A	I	Moderate Snow	Aluminum	-3	20°C	25	-
207	1	Octuplet	PG ADF Concentrate	33/67	097A	I	Moderate Snow	Aluminum	-3	20°C	25	-
208	1	Octuplet	PG ADF Concentrate	33/67	097A	I	Moderate Snow	Aluminum	-3	20°C	25	-
209	1	Duplicate	PG ADF Concentrate	33/67	097A	I	Moderate Snow	Composite	-3	20°C	25	-
210	1	Duplicate	PG ADF Concentrate	33/67	097A	I	Moderate Snow	Composite	-3	20°C	25	-
211	1	Quadruplet	PG ADF Concentrate	33/67	097A	I	Moderate Snow	Composite	-3	20°C	25	-
212	1	Quadruplet	PG ADF Concentrate	33/67	097A	I	Moderate Snow	Composite	-3	20°C	25	-
213	1	Octuplet	PG ADF Concentrate	33/67	097A	I	Moderate Snow	Composite	-3	20°C	25	-
214	1	Octuplet	PG ADF Concentrate	33/67	097A	I	Moderate Snow	Composite	-3	20°C	25	-
215	1	Octuplet	PG ADF Concentrate	33/67	097A	I	Moderate Snow	Composite	-3	20°C	25	-
216	1	Octuplet	PG ADF Concentrate	33/67	097A	I	Moderate Snow	Composite	-3	20°C	25	-
217	1	Duplicate	Safewing MP II FLIGHT	100/0	023A	II	Moderate Snow	Aluminum	-3	OAT	25	-
218	1	Duplicate	Safewing MP II FLIGHT	100/0	023A	II	Moderate Snow	Aluminum	-3	OAT	25	-
219	1	Quadruplet	Safewing MP II FLIGHT	100/0	023A	II	Moderate Snow	Aluminum	-3	OAT	25	-
220	1	Quadruplet	Safewing MP II FLIGHT	100/0	023A	II	Moderate Snow	Aluminum	-3	OAT	25	-
221	1	Octuplet	Safewing MP II FLIGHT	100/0	023A	II	Moderate Snow	Aluminum	-3	OAT	25	-
222	1	Octuplet	Safewing MP II FLIGHT	100/0	023A	II	Moderate Snow	Aluminum	-3	OAT	25	-
223	1	Octuplet	Safewing MP II FLIGHT	100/0	023A	II	Moderate Snow	Aluminum	-3	OAT	25	-

Attachment 3: Proposed Test Plan for Testing Snow Mixed with Freezing Fog (cont'd)

Test No.	Priority	Test Type	Fluid	Dilution	APS Fluid Code	Fluid Type	Precipitation	Test Surface	Test Temp. (°C)	Fluid Temp. (°C)	Snow Rate (g/dm²/h)	Freezing Fog Rate (g/dm²/h)
224	1	Octuplet	Safewing MP II FLIGHT	100/0	023A	II	Moderate Snow	Aluminum	-3	OAT	25	-
225	1	Calibration	AeroClear MAX	100/0	063A	III	Moderate Snow	Aluminum	-3	OAT	25	-
226	1	Calibration	AeroClear MAX	100/0	063A	III	Moderate Snow	Aluminum	-3	OAT	25	-
227	1	Calibration	AeroClear MAX	100/0	063A	III	Moderate Snow	Aluminum	-3	OAT	25	-
228	1	Calibration	AeroClear MAX	100/0	063A	III	Moderate Snow	Aluminum	-3	OAT	25	-
229	1	Calibration	AeroClear MAX	100/0	063A	III	Moderate Snow	Aluminum	-3	OAT	25	-
230	1	Calibration	AeroClear MAX	100/0	063A	III	Moderate Snow	Aluminum	-3	OAT	25	-
231	1	Calibration	AeroClear MAX	100/0	063A	III	Moderate Snow	Aluminum	-3	OAT	25	-
232	1	Calibration	AeroClear MAX	100/0	063A	III	Moderate Snow	Aluminum	-3	OAT	25	-
233	1	Calibration	AeroClear MAX	100/0	063A	III	Moderate Snow	Aluminum	-3	OAT	25	-
234	1	Calibration	AeroClear MAX	100/0	063A	III	Moderate Snow	Aluminum	-3	OAT	25	-
235	1	Calibration	AeroClear MAX	100/0	063A	III	Moderate Snow	Aluminum	-3	OAT	25	-
236	1	Calibration	AeroClear MAX	100/0	063A	III	Moderate Snow	Aluminum	-3	OAT	25	-
237	1	Duplicate	Polar Guard Advance	100/0	090A	IV	Moderate Snow	Aluminum	-3	OAT	25	-
238	1	Duplicate	Polar Guard Advance	100/0	090A	IV	Moderate Snow	Aluminum	-3	OAT	25	-
239	1	Quadruplet	Polar Guard Advance	100/0	090A	IV	Moderate Snow	Aluminum	-3	OAT	25	-
240	1	Quadruplet	Polar Guard Advance	100/0	090A	IV	Moderate Snow	Aluminum	-3	OAT	25	-
241	1	Octuplet	Polar Guard Advance	100/0	090A	IV	Moderate Snow	Aluminum	-3	OAT	25	-
242	1	Octuplet	Polar Guard Advance	100/0	090A	IV	Moderate Snow	Aluminum	-3	OAT	25	-
243	1	Octuplet	Polar Guard Advance	100/0	090A	IV	Moderate Snow	Aluminum	-3	OAT	25	-
244	1	Octuplet	Polar Guard Advance	100/0	090A	IV	Moderate Snow	Aluminum	-3	OAT	25	-
245	1	Duplicate	EG106	100/0	096A	IV	Moderate Snow	Aluminum	-3	OAT	25	-
246	1	Duplicate	EG106	100/0	096A	IV	Moderate Snow	Aluminum	-3	OAT	25	-
247	1	Quadruplet	EG106	100/0	096A	IV	Moderate Snow	Aluminum	-3	OAT	25	-
248	1	Quadruplet	EG106	100/0	096A	IV	Moderate Snow	Aluminum	-3	OAT	25	-
249	1	Octuplet	EG106	100/0	096A	IV	Moderate Snow	Aluminum	-3	OAT	25	-
250	1	Octuplet	EG106	100/0	096A	IV	Moderate Snow	Aluminum	-3	OAT	25	-
251	1	Octuplet	EG106	100/0	096A	IV	Moderate Snow	Aluminum	-3	OAT	25	-
252	1	Octuplet	EG106	100/0	096A	IV	Moderate Snow	Aluminum	-3	OAT	25	-
253	1	Duplicate	PG ADF Concentrate	46/54	097A	I	Light Snow	Aluminum	-14	20°C	10	-
254	1	Duplicate	PG ADF Concentrate	46/54	097A	I	Light Snow	Aluminum	-14	20°C	10	-
255	1	Quadruplet	PG ADF Concentrate	46/54	097A	I	Light Snow	Aluminum	-14	20°C	10	-

Attachment 3: Proposed Test Plan for Testing Snow Mixed with Freezing Fog (cont'd)

Test No.	Priority	Test Type	Fluid	Dilution	APS Fluid Code	Fluid Type	Precipitation	Test Surface	Test Temp. (°C)	Fluid Temp. (°C)	Snow Rate (g/dm²/h)	Freezing Fog Rate (g/dm²/h)
256	1	Quadruplet	PG ADF Concentrate	46/54	097A	I	Light Snow	Aluminum	-14	20°C	10	-
257	1	Octuplet	PG ADF Concentrate	46/54	097A	I	Light Snow	Aluminum	-14	20°C	10	-
258	1	Octuplet	PG ADF Concentrate	46/54	097A	I	Light Snow	Aluminum	-14	20°C	10	-
259	1	Octuplet	PG ADF Concentrate	46/54	097A	I	Light Snow	Aluminum	-14	20°C	10	-
260	1	Octuplet	PG ADF Concentrate	46/54	097A	I	Light Snow	Aluminum	-14	20°C	10	-
261	1	Duplicate	PG ADF Concentrate	46/54	097A	I	Light Snow	Composite	-14	20°C	10	-
262	1	Duplicate	PG ADF Concentrate	46/54	097A	I	Light Snow	Composite	-14	20°C	10	-
263	1	Quadruplet	PG ADF Concentrate	46/54	097A	I	Light Snow	Composite	-14	20°C	10	-
264	1	Quadruplet	PG ADF Concentrate	46/54	097A	I	Light Snow	Composite	-14	20°C	10	-
265	1	Octuplet	PG ADF Concentrate	46/54	097A	I	Light Snow	Composite	-14	20°C	10	-
266	1	Octuplet	PG ADF Concentrate	46/54	097A	I	Light Snow	Composite	-14	20°C	10	-
267	1	Octuplet	PG ADF Concentrate	46/54	097A	I	Light Snow	Composite	-14	20°C	10	-
268	1	Octuplet	PG ADF Concentrate	46/54	097A	I	Light Snow	Composite	-14	20°C	10	-
269	1	Duplicate	Safewing MP II FLIGHT	100/0	023A	II	Light Snow	Aluminum	-14	OAT	10	-
270	1	Duplicate	Safewing MP II FLIGHT	100/0	023A	II	Light Snow	Aluminum	-14	OAT	10	-
271	1	Quadruplet	Safewing MP II FLIGHT	100/0	023A	II	Light Snow	Aluminum	-14	OAT	10	-
272	1	Quadruplet	Safewing MP II FLIGHT	100/0	023A	II	Light Snow	Aluminum	-14	OAT	10	-
273	1	Octuplet	Safewing MP II FLIGHT	100/0	023A	II	Light Snow	Aluminum	-14	OAT	10	-
274	1	Octuplet	Safewing MP II FLIGHT	100/0	023A	II	Light Snow	Aluminum	-14	OAT	10	-
275	1	Octuplet	Safewing MP II FLIGHT	100/0	023A	II	Light Snow	Aluminum	-14	OAT	10	-
276	1	Octuplet	Safewing MP II FLIGHT	100/0	023A	II	Light Snow	Aluminum	-14	OAT	10	-
277	1	Duplicate	AeroClear MAX	100/0	067A	III	Light Snow	Aluminum	-14	OAT	10	-
278	1	Duplicate	AeroClear MAX	100/0	067A	III	Light Snow	Aluminum	-14	OAT	10	-
279	1	Quadruplet	AeroClear MAX	100/0	067A	III	Light Snow	Aluminum	-14	OAT	10	-
280	1	Quadruplet	AeroClear MAX	100/0	067A	III	Light Snow	Aluminum	-14	OAT	10	-
281	1	Octuplet	AeroClear MAX	100/0	067A	III	Light Snow	Aluminum	-14	OAT	10	-
282	1	Octuplet	AeroClear MAX	100/0	067A	III	Light Snow	Aluminum	-14	OAT	10	-
283	1	Octuplet	AeroClear MAX	100/0	067A	III	Light Snow	Aluminum	-14	OAT	10	-
284	1	Octuplet	AeroClear MAX	100/0	067A	III	Light Snow	Aluminum	-14	OAT	10	-
285	1	Duplicate	Polar Guard Advance	100/0	090A	IV	Light Snow	Aluminum	-14	OAT	10	-
286	1	Duplicate	Polar Guard Advance	100/0	090A	IV	Light Snow	Aluminum	-14	OAT	10	-
287	1	Quadruplet	Polar Guard Advance	100/0	090A	IV	Light Snow	Aluminum	-14	OAT	10	-

Attachment 3: Proposed Test Plan for Testing Snow Mixed with Freezing Fog (cont'd)

Test No.	Priority	Test Type	Fluid	Dilution	APS Fluid Code	Fluid Type	Precipitation	Test Surface	Test Temp. (°C)	Fluid Temp. (°C)	Snow Rate (g/dm²/h)	Freezing Fog Rate (g/dm²/h)
288	1	Quadruplet	Polar Guard Advance	100/0	090A	IV	Light Snow	Aluminum	-14	OAT	10	-
289	1	Octuplet	Polar Guard Advance	100/0	090A	IV	Light Snow	Aluminum	-14	OAT	10	-
290	1	Octuplet	Polar Guard Advance	100/0	090A	IV	Light Snow	Aluminum	-14	OAT	10	-
291	1	Octuplet	Polar Guard Advance	100/0	090A	IV	Light Snow	Aluminum	-14	OAT	10	-
292	1	Octuplet	Polar Guard Advance	100/0	090A	IV	Light Snow	Aluminum	-14	OAT	10	-
293	1	Duplicate	EG106	100/0	096A	IV	Light Snow	Aluminum	-14	OAT	10	-
294	1	Duplicate	EG106	100/0	096A	IV	Light Snow	Aluminum	-14	OAT	10	-
295	1	Quadruplet	EG106	100/0	096A	IV	Light Snow	Aluminum	-14	OAT	10	-
296	1	Quadruplet	EG106	100/0	096A	IV	Light Snow	Aluminum	-14	OAT	10	-
297	1	Octuplet	EG106	100/0	096A	IV	Light Snow	Aluminum	-14	OAT	10	-
298	1	Octuplet	EG106	100/0	096A	IV	Light Snow	Aluminum	-14	OAT	10	-
299	1	Octuplet	EG106	100/0	096A	IV	Light Snow	Aluminum	-14	OAT	10	-
300	1	Octuplet	EG106	100/0	096A	IV	Light Snow	Aluminum	-14	OAT	10	-
301	1	Duplicate	PG ADF Concentrate	46/54	097A	I	Moderate Snow	Aluminum	-14	20°C	25	-
302	1	Duplicate	PG ADF Concentrate	46/54	097A	I	Moderate Snow	Aluminum	-14	20°C	25	-
303	1	Quadruplet	PG ADF Concentrate	46/54	097A	I	Moderate Snow	Aluminum	-14	20°C	25	-
304	1	Quadruplet	PG ADF Concentrate	46/54	097A	I	Moderate Snow	Aluminum	-14	20°C	25	-
305	1	Octuplet	PG ADF Concentrate	46/54	097A	I	Moderate Snow	Aluminum	-14	20°C	25	-
306	1	Octuplet	PG ADF Concentrate	46/54	097A	I	Moderate Snow	Aluminum	-14	20°C	25	-
307	1	Octuplet	PG ADF Concentrate	46/54	097A	I	Moderate Snow	Aluminum	-14	20°C	25	-
308	1	Octuplet	PG ADF Concentrate	46/54	097A	I	Moderate Snow	Aluminum	-14	20°C	25	-
309	1	Duplicate	PG ADF Concentrate	46/54	097A	I	Moderate Snow	Composite	-14	20°C	25	-
310	1	Duplicate	PG ADF Concentrate	46/54	097A	I	Moderate Snow	Composite	-14	20°C	25	-
311	1	Quadruplet	PG ADF Concentrate	46/54	097A	I	Moderate Snow	Composite	-14	20°C	25	-
312	1	Quadruplet	PG ADF Concentrate	46/54	097A	I	Moderate Snow	Composite	-14	20°C	25	-
313	1	Octuplet	PG ADF Concentrate	46/54	097A	I	Moderate Snow	Composite	-14	20°C	25	-
314	1	Octuplet	PG ADF Concentrate	46/54	097A	I	Moderate Snow	Composite	-14	20°C	25	-
315	1	Octuplet	PG ADF Concentrate	46/54	097A	I	Moderate Snow	Composite	-14	20°C	25	-
316	1	Octuplet	PG ADF Concentrate	46/54	097A	I	Moderate Snow	Composite	-14	20°C	25	-
317	1	Duplicate	Safewing MP II FLIGHT	100/0	023A	II	Moderate Snow	Aluminum	-14	OAT	25	-
318	1	Duplicate	Safewing MP II FLIGHT	100/0	023A	II	Moderate Snow	Aluminum	-14	OAT	25	-
319	1	Quadruplet	Safewing MP II FLIGHT	100/0	023A	II	Moderate Snow	Aluminum	-14	OAT	25	-

Attachment 3: Proposed Test Plan for Testing Snow Mixed with Freezing Fog (cont'd)

Test No.	Priority	Test Type	Fluid	Dilution	APS Fluid Code	Fluid Type	Precipitation	Test Surface	Test Temp. (°C)	Fluid Temp. (°C)	Snow Rate (g/dm²/h)	Freezing Fog Rate (g/dm²/h)
320	1	Quadruplet	Safewing MP II FLIGHT	100/0	023A	II	Moderate Snow	Aluminum	-14	OAT	25	-
321	1	Octuplet	Safewing MP II FLIGHT	100/0	023A	II	Moderate Snow	Aluminum	-14	OAT	25	-
322	1	Octuplet	Safewing MP II FLIGHT	100/0	023A	II	Moderate Snow	Aluminum	-14	OAT	25	-
323	1	Octuplet	Safewing MP II FLIGHT	100/0	023A	II	Moderate Snow	Aluminum	-14	OAT	25	-
324	1	Octuplet	Safewing MP II FLIGHT	100/0	023A	II	Moderate Snow	Aluminum	-14	OAT	25	-
325	1	Duplicate	AeroClear MAX	100/0	067A	III	Moderate Snow	Aluminum	-14	OAT	25	-
326	1	Duplicate	AeroClear MAX	100/0	067A	III	Moderate Snow	Aluminum	-14	OAT	25	-
327	1	Quadruplet	AeroClear MAX	100/0	067A	III	Moderate Snow	Aluminum	-14	OAT	25	-
328	1	Quadruplet	AeroClear MAX	100/0	067A	III	Moderate Snow	Aluminum	-14	OAT	25	-
329	1	Octuplet	AeroClear MAX	100/0	067A	III	Moderate Snow	Aluminum	-14	OAT	25	-
330	1	Octuplet	AeroClear MAX	100/0	067A	III	Moderate Snow	Aluminum	-14	OAT	25	-
331	1	Octuplet	AeroClear MAX	100/0	067A	III	Moderate Snow	Aluminum	-14	OAT	25	-
332	1	Octuplet	AeroClear MAX	100/0	067A	III	Moderate Snow	Aluminum	-14	OAT	25	-
333	1	Duplicate	Polar Guard Advance	100/0	090A	IV	Moderate Snow	Aluminum	-14	OAT	25	-
334	1	Duplicate	Polar Guard Advance	100/0	090A	IV	Moderate Snow	Aluminum	-14	OAT	25	-
335	1	Quadruplet	Polar Guard Advance	100/0	090A	IV	Moderate Snow	Aluminum	-14	OAT	25	-
336	1	Quadruplet	Polar Guard Advance	100/0	090A	IV	Moderate Snow	Aluminum	-14	OAT	25	-
337	1	Octuplet	Polar Guard Advance	100/0	090A	IV	Moderate Snow	Aluminum	-14	OAT	25	-
338	1	Octuplet	Polar Guard Advance	100/0	090A	IV	Moderate Snow	Aluminum	-14	OAT	25	-
339	1	Octuplet	Polar Guard Advance	100/0	090A	IV	Moderate Snow	Aluminum	-14	OAT	25	-
340	1	Octuplet	Polar Guard Advance	100/0	090A	IV	Moderate Snow	Aluminum	-14	OAT	25	-
341	1	Duplicate	EG106	100/0	096A	IV	Moderate Snow	Aluminum	-14	OAT	25	-
342	1	Duplicate	EG106	100/0	096A	IV	Moderate Snow	Aluminum	-14	OAT	25	-
343	1	Quadruplet	EG106	100/0	096A	IV	Moderate Snow	Aluminum	-14	OAT	25	-
344	1	Quadruplet	EG106	100/0	096A	IV	Moderate Snow	Aluminum	-14	OAT	25	-
345	1	Octuplet	EG106	100/0	096A	IV	Moderate Snow	Aluminum	-14	OAT	25	-
346	1	Octuplet	EG106	100/0	096A	IV	Moderate Snow	Aluminum	-14	OAT	25	-
347	1	Octuplet	EG106	100/0	096A	IV	Moderate Snow	Aluminum	-14	OAT	25	-
348	1	Octuplet	EG106	100/0	096A	IV	Moderate Snow	Aluminum	-14	OAT	25	-
349	2	Duplicate	PG ADF Concentrate	55/45	097A	I	Light Snow	Aluminum	-25	20°C	10	-
350	2	Duplicate	PG ADF Concentrate	55/45	097A	I	Light Snow	Aluminum	-25	20°C	10	-
351	2	Quadruplet	PG ADF Concentrate	55/45	097A	I	Light Snow	Aluminum	-25	20°C	10	-

Attachment 3: Proposed Test Plan for Testing Snow Mixed with Freezing Fog (cont'd)

Test No.	Priority	Test Type	Fluid	Dilution	APS Fluid Code	Fluid Type	Precipitation	Test Surface	Test Temp. (°C)	Fluid Temp. (°C)	Snow Rate (g/dm²/h)	Freezing Fog Rate (g/dm²/h)
352	2	Quadruplet	PG ADF Concentrate	55/45	097A	I	Light Snow	Aluminum	-25	20°C	10	-
353	2	Octuplet	PG ADF Concentrate	55/45	097A	I	Light Snow	Aluminum	-25	20°C	10	-
354	2	Octuplet	PG ADF Concentrate	55/45	097A	I	Light Snow	Aluminum	-25	20°C	10	-
355	2	Octuplet	PG ADF Concentrate	55/45	097A	I	Light Snow	Aluminum	-25	20°C	10	-
356	2	Octuplet	PG ADF Concentrate	55/45	097A	I	Light Snow	Aluminum	-25	20°C	10	-
357	2	Duplicate	PG ADF Concentrate	55/45	097A	I	Light Snow	Composite	-25	20°C	10	-
358	2	Duplicate	PG ADF Concentrate	55/45	097A	I	Light Snow	Composite	-25	20°C	10	-
359	2	Quadruplet	PG ADF Concentrate	55/45	097A	I	Light Snow	Composite	-25	20°C	10	-
360	2	Quadruplet	PG ADF Concentrate	55/45	097A	I	Light Snow	Composite	-25	20°C	10	-
361	2	Octuplet	PG ADF Concentrate	55/45	097A	I	Light Snow	Composite	-25	20°C	10	-
362	2	Octuplet	PG ADF Concentrate	55/45	097A	I	Light Snow	Composite	-25	20°C	10	-
363	2	Octuplet	PG ADF Concentrate	55/45	097A	I	Light Snow	Composite	-25	20°C	10	-
364	2	Octuplet	PG ADF Concentrate	55/45	097A	I	Light Snow	Composite	-25	20°C	10	-
365	2	Duplicate	Safewing MP II FLIGHT	100/0	023A	II	Light Snow	Aluminum	-25	OAT	10	-
366	2	Duplicate	Safewing MP II FLIGHT	100/0	023A	II	Light Snow	Aluminum	-25	OAT	10	-
367	2	Quadruplet	Safewing MP II FLIGHT	100/0	023A	II	Light Snow	Aluminum	-25	OAT	10	-
368	2	Quadruplet	Safewing MP II FLIGHT	100/0	023A	II	Light Snow	Aluminum	-25	OAT	10	-
369	2	Octuplet	Safewing MP II FLIGHT	100/0	023A	II	Light Snow	Aluminum	-25	OAT	10	-
370	2	Octuplet	Safewing MP II FLIGHT	100/0	023A	II	Light Snow	Aluminum	-25	OAT	10	-
371	2	Octuplet	Safewing MP II FLIGHT	100/0	023A	II	Light Snow	Aluminum	-25	OAT	10	-
372	2	Octuplet	Safewing MP II FLIGHT	100/0	023A	II	Light Snow	Aluminum	-25	OAT	10	-
373	2	Duplicate	AeroClear MAX	100/0	067A	III	Light Snow	Aluminum	-25	OAT	10	-
374	2	Duplicate	AeroClear MAX	100/0	067A	III	Light Snow	Aluminum	-25	OAT	10	-
375	2	Quadruplet	AeroClear MAX	100/0	067A	III	Light Snow	Aluminum	-25	OAT	10	-
376	2	Quadruplet	AeroClear MAX	100/0	067A	III	Light Snow	Aluminum	-25	OAT	10	-
377	2	Octuplet	AeroClear MAX	100/0	067A	III	Light Snow	Aluminum	-25	OAT	10	-
378	2	Octuplet	AeroClear MAX	100/0	067A	III	Light Snow	Aluminum	-25	OAT	10	-
379	2	Octuplet	AeroClear MAX	100/0	067A	III	Light Snow	Aluminum	-25	OAT	10	-
380	2	Octuplet	AeroClear MAX	100/0	067A	III	Light Snow	Aluminum	-25	OAT	10	-
381	2	Duplicate	Polar Guard Advance	100/0	090A	IV	Light Snow	Aluminum	-25	OAT	10	-
382	2	Duplicate	Polar Guard Advance	100/0	090A	IV	Light Snow	Aluminum	-25	OAT	10	-
383	2	Quadruplet	Polar Guard Advance	100/0	090A	IV	Light Snow	Aluminum	-25	OAT	10	-

Attachment 3: Proposed Test Plan for Testing Snow Mixed with Freezing Fog (cont'd)

Test No.	Priority	Test Type	Fluid	Dilution	APS Fluid Code	Fluid Type	Precipitation	Test Surface	Test Temp. (°C)	Fluid Temp. (°C)	Snow Rate (g/dm²/h)	Freezing Fog Rate (g/dm²/h)
384	2	Quadruplet	Polar Guard Advance	100/0	090A	IV	Light Snow	Aluminum	-25	OAT	10	-
385	2	Octuplet	Polar Guard Advance	100/0	090A	IV	Light Snow	Aluminum	-25	OAT	10	-
386	2	Octuplet	Polar Guard Advance	100/0	090A	IV	Light Snow	Aluminum	-25	OAT	10	-
387	2	Octuplet	Polar Guard Advance	100/0	090A	IV	Light Snow	Aluminum	-25	OAT	10	-
388	2	Octuplet	Polar Guard Advance	100/0	090A	IV	Light Snow	Aluminum	-25	OAT	10	-
389	2	Duplicate	EG106	100/0	096A	IV	Light Snow	Aluminum	-25	OAT	10	-
390	2	Duplicate	EG106	100/0	096A	IV	Light Snow	Aluminum	-25	OAT	10	-
391	2	Quadruplet	EG106	100/0	096A	IV	Light Snow	Aluminum	-25	OAT	10	-
392	2	Quadruplet	EG106	100/0	096A	IV	Light Snow	Aluminum	-25	OAT	10	-
393	2	Octuplet	EG106	100/0	096A	IV	Light Snow	Aluminum	-25	OAT	10	-
394	2	Octuplet	EG106	100/0	096A	IV	Light Snow	Aluminum	-25	OAT	10	-
395	2	Octuplet	EG106	100/0	096A	IV	Light Snow	Aluminum	-25	OAT	10	-
396	2	Octuplet	EG106	100/0	096A	IV	Light Snow	Aluminum	-25	OAT	10	-
397	2	Duplicate	PG ADF Concentrate	55/45	097A	I	Moderate Snow	Aluminum	-25	20°C	25	-
398	2	Duplicate	PG ADF Concentrate	55/45	097A	I	Moderate Snow	Aluminum	-25	20°C	25	-
399	2	Quadruplet	PG ADF Concentrate	55/45	097A	I	Moderate Snow	Aluminum	-25	20°C	25	-
400	2	Quadruplet	PG ADF Concentrate	55/45	097A	I	Moderate Snow	Aluminum	-25	20°C	25	-
401	2	Octuplet	PG ADF Concentrate	55/45	097A	I	Moderate Snow	Aluminum	-25	20°C	25	-
402	2	Octuplet	PG ADF Concentrate	55/45	097A	I	Moderate Snow	Aluminum	-25	20°C	25	-
403	2	Octuplet	PG ADF Concentrate	55/45	097A	I	Moderate Snow	Aluminum	-25	20°C	25	-
404	2	Octuplet	PG ADF Concentrate	55/45	097A	I	Moderate Snow	Aluminum	-25	20°C	25	-
405	2	Duplicate	PG ADF Concentrate	55/45	097A	I	Moderate Snow	Composite	-25	20°C	25	-
406	2	Duplicate	PG ADF Concentrate	55/45	097A	I	Moderate Snow	Composite	-25	20°C	25	-
407	2	Quadruplet	PG ADF Concentrate	55/45	097A	I	Moderate Snow	Composite	-25	20°C	25	-
408	2	Quadruplet	PG ADF Concentrate	55/45	097A	I	Moderate Snow	Composite	-25	20°C	25	-
409	2	Octuplet	PG ADF Concentrate	55/45	097A	I	Moderate Snow	Composite	-25	20°C	25	-
410	2	Octuplet	PG ADF Concentrate	55/45	097A	I	Moderate Snow	Composite	-25	20°C	25	-
411	2	Octuplet	PG ADF Concentrate	55/45	097A	I	Moderate Snow	Composite	-25	20°C	25	-
412	2	Octuplet	PG ADF Concentrate	55/45	097A	I	Moderate Snow	Composite	-25	20°C	25	-
413	2	Duplicate	Safewing MP II FLIGHT	100/0	023A	II	Moderate Snow	Aluminum	-25	OAT	25	-
414	2	Duplicate	Safewing MP II FLIGHT	100/0	023A	II	Moderate Snow	Aluminum	-25	OAT	25	-
415	2	Quadruplet	Safewing MP II FLIGHT	100/0	023A	II	Moderate Snow	Aluminum	-25	OAT	25	-

Attachment 3: Proposed Test Plan for Testing Snow Mixed with Freezing Fog (cont'd)

Test No.	Priority	Test Type	Fluid	Dilution	APS Fluid Code	Fluid Type	Precipitation	Test Surface	Test Temp. (°C)	Fluid Temp. (°C)	Snow Rate (g/dm²/h)	Freezing Fog Rate (g/dm²/h)
416	2	Quadruplet	Safewing MP II FLIGHT	100/0	023A	II	Moderate Snow	Aluminum	-25	OAT	25	-
417	2	Octuplet	Safewing MP II FLIGHT	100/0	023A	II	Moderate Snow	Aluminum	-25	OAT	25	-
418	2	Octuplet	Safewing MP II FLIGHT	100/0	023A	II	Moderate Snow	Aluminum	-25	OAT	25	-
419	2	Octuplet	Safewing MP II FLIGHT	100/0	023A	II	Moderate Snow	Aluminum	-25	OAT	25	-
420	2	Octuplet	Safewing MP II FLIGHT	100/0	023A	II	Moderate Snow	Aluminum	-25	OAT	25	-
421	2	Duplicate	AeroClear MAX	100/0	067A	III	Moderate Snow	Aluminum	-25	OAT	25	-
422	2	Duplicate	AeroClear MAX	100/0	067A	III	Moderate Snow	Aluminum	-25	OAT	25	-
423	2	Quadruplet	AeroClear MAX	100/0	067A	III	Moderate Snow	Aluminum	-25	OAT	25	-
424	2	Quadruplet	AeroClear MAX	100/0	067A	III	Moderate Snow	Aluminum	-25	OAT	25	-
425	2	Octuplet	AeroClear MAX	100/0	067A	III	Moderate Snow	Aluminum	-25	OAT	25	-
426	2	Octuplet	AeroClear MAX	100/0	067A	III	Moderate Snow	Aluminum	-25	OAT	25	-
427	2	Octuplet	AeroClear MAX	100/0	067A	III	Moderate Snow	Aluminum	-25	OAT	25	-
428	2	Octuplet	AeroClear MAX	100/0	067A	III	Moderate Snow	Aluminum	-25	OAT	25	-
429	2	Duplicate	Polar Guard Advance	100/0	090A	IV	Moderate Snow	Aluminum	-25	OAT	25	-
430	2	Duplicate	Polar Guard Advance	100/0	090A	IV	Moderate Snow	Aluminum	-25	OAT	25	-
431	2	Quadruplet	Polar Guard Advance	100/0	090A	IV	Moderate Snow	Aluminum	-25	OAT	25	-
432	2	Quadruplet	Polar Guard Advance	100/0	090A	IV	Moderate Snow	Aluminum	-25	OAT	25	-
433	2	Octuplet	Polar Guard Advance	100/0	090A	IV	Moderate Snow	Aluminum	-25	OAT	25	-
434	2	Octuplet	Polar Guard Advance	100/0	090A	IV	Moderate Snow	Aluminum	-25	OAT	25	-
435	2	Octuplet	Polar Guard Advance	100/0	090A	IV	Moderate Snow	Aluminum	-25	OAT	25	-
436	2	Octuplet	Polar Guard Advance	100/0	090A	IV	Moderate Snow	Aluminum	-25	OAT	25	-
437	2	Duplicate	EG106	100/0	096A	IV	Moderate Snow	Aluminum	-25	OAT	25	-
438	2	Duplicate	EG106	100/0	096A	IV	Moderate Snow	Aluminum	-25	OAT	25	-
439	2	Quadruplet	EG106	100/0	096A	IV	Moderate Snow	Aluminum	-25	OAT	25	-
440	2	Quadruplet	EG106	100/0	096A	IV	Moderate Snow	Aluminum	-25	OAT	25	-
441	2	Octuplet	EG106	100/0	096A	IV	Moderate Snow	Aluminum	-25	OAT	25	-
442	2	Octuplet	EG106	100/0	096A	IV	Moderate Snow	Aluminum	-25	OAT	25	-
443	2	Octuplet	EG106	100/0	096A	IV	Moderate Snow	Aluminum	-25	OAT	25	-
444	2	Octuplet	EG106	100/0	096A	IV	Moderate Snow	Aluminum	-25	OAT	25	-
445	1	Duplicate	PG ADF Concentrate	33/67	097A	I	Light Snow + Freezing Fog	Aluminum	-3	20°C	5	5
446	1	Duplicate	PG ADF Concentrate	33/67	097A	I	Light Snow + Freezing Fog	Aluminum	-3	20°C	5	5
447	1	Quadruplet	PG ADF Concentrate	33/67	097A	I	Light Snow + Freezing Fog	Aluminum	-3	20°C	5	5

Attachment 3: Proposed Test Plan for Testing Snow Mixed with Freezing Fog (cont'd)

Test No.	Priority	Test Type	Fluid	Dilution	APS Fluid Code	Fluid Type	Precipitation	Test Surface	Test Temp. (°C)	Fluid Temp. (°C)	Snow Rate (g/dm²/h)	Freezing Fog Rate (g/dm²/h)
448	1	Quadruplet	PG ADF Concentrate	33/67	097A	I	Light Snow + Freezing Fog	Aluminum	-3	20°C	5	5
449	1	Octuplet	PG ADF Concentrate	33/67	097A	I	Light Snow + Freezing Fog	Aluminum	-3	20°C	5	5
450	1	Octuplet	PG ADF Concentrate	33/67	097A	I	Light Snow + Freezing Fog	Aluminum	-3	20°C	5	5
451	1	Octuplet	PG ADF Concentrate	33/67	097A	I	Light Snow + Freezing Fog	Aluminum	-3	20°C	5	5
452	1	Octuplet	PG ADF Concentrate	33/67	097A	I	Light Snow + Freezing Fog	Aluminum	-3	20°C	5	5
453	1	Duplicate	PG ADF Concentrate	33/67	097A	I	Light Snow + Freezing Fog	Composite	-3	20°C	5	5
454	1	Duplicate	PG ADF Concentrate	33/67	097A	I	Light Snow + Freezing Fog	Composite	-3	20°C	5	5
455	1	Quadruplet	PG ADF Concentrate	33/67	097A	I	Light Snow + Freezing Fog	Composite	-3	20°C	5	5
456	1	Quadruplet	PG ADF Concentrate	33/67	097A	I	Light Snow + Freezing Fog	Composite	-3	20°C	5	5
457	1	Octuplet	PG ADF Concentrate	33/67	097A	I	Light Snow + Freezing Fog	Composite	-3	20°C	5	5
458	1	Octuplet	PG ADF Concentrate	33/67	097A	I	Light Snow + Freezing Fog	Composite	-3	20°C	5	5
459	1	Octuplet	PG ADF Concentrate	33/67	097A	I	Light Snow + Freezing Fog	Composite	-3	20°C	5	5
460	1	Octuplet	PG ADF Concentrate	33/67	097A	I	Light Snow + Freezing Fog	Composite	-3	20°C	5	5
461	1	Duplicate	Safewing MP II FLIGHT	100/0	023A	II	Light Snow + Freezing Fog	Aluminum	-3	OAT	5	5
462	1	Duplicate	Safewing MP II FLIGHT	100/0	023A	II	Light Snow + Freezing Fog	Aluminum	-3	OAT	5	5
463	1	Quadruplet	Safewing MP II FLIGHT	100/0	023A	II	Light Snow + Freezing Fog	Aluminum	-3	OAT	5	5
464	1	Quadruplet	Safewing MP II FLIGHT	100/0	023A	II	Light Snow + Freezing Fog	Aluminum	-3	OAT	5	5
465	1	Octuplet	Safewing MP II FLIGHT	100/0	023A	II	Light Snow + Freezing Fog	Aluminum	-3	OAT	5	5
466	1	Octuplet	Safewing MP II FLIGHT	100/0	023A	II	Light Snow + Freezing Fog	Aluminum	-3	OAT	5	5
467	1	Octuplet	Safewing MP II FLIGHT	100/0	023A	II	Light Snow + Freezing Fog	Aluminum	-3	OAT	5	5
468	1	Octuplet	Safewing MP II FLIGHT	100/0	023A	II	Light Snow + Freezing Fog	Aluminum	-3	OAT	5	5
469	1	Calibration	AeroClear MAX	100/0	063A	III	Light Snow + Freezing Fog	Aluminum	-3	OAT	5	5
470	1	Calibration	AeroClear MAX	100/0	063A	III	Light Snow + Freezing Fog	Aluminum	-3	OAT	5	5
471	1	Calibration	AeroClear MAX	100/0	063A	III	Light Snow + Freezing Fog	Aluminum	-3	OAT	5	5
472	1	Calibration	AeroClear MAX	100/0	063A	III	Light Snow + Freezing Fog	Aluminum	-3	OAT	5	5
473	1	Calibration	AeroClear MAX	100/0	063A	III	Light Snow + Freezing Fog	Aluminum	-3	OAT	5	5
474	1	Calibration	AeroClear MAX	100/0	063A	III	Light Snow + Freezing Fog	Aluminum	-3	OAT	5	5
475	1	Calibration	AeroClear MAX	100/0	063A	III	Light Snow + Freezing Fog	Aluminum	-3	OAT	5	5
476	1	Calibration	AeroClear MAX	100/0	063A	III	Light Snow + Freezing Fog	Aluminum	-3	OAT	5	5
477	1	Calibration	AeroClear MAX	100/0	063A	III	Light Snow + Freezing Fog	Aluminum	-3	OAT	5	5
478	1	Calibration	AeroClear MAX	100/0	063A	III	Light Snow + Freezing Fog	Aluminum	-3	OAT	5	5
479	1	Calibration	AeroClear MAX	100/0	063A	III	Light Snow + Freezing Fog	Aluminum	-3	OAT	5	5

Attachment 3: Proposed Test Plan for Testing Snow Mixed with Freezing Fog (cont'd)

Test No.	Priority	Test Type	Fluid	Dilution	APS Fluid Code	Fluid Type	Precipitation	Test Surface	Test Temp. (°C)	Fluid Temp. (°C)	Snow Rate (g/dm²/h)	Freezing Fog Rate (g/dm²/h)
480	1	Calibration	AeroClear MAX	100/0	063A	III	Light Snow + Freezing Fog	Aluminum	-3	OAT	5	5
481	1	Duplicate	Polar Guard Advance	100/0	090A	IV	Light Snow + Freezing Fog	Aluminum	-3	OAT	5	5
482	1	Duplicate	Polar Guard Advance	100/0	090A	IV	Light Snow + Freezing Fog	Aluminum	-3	OAT	5	5
483	1	Quadruplet	Polar Guard Advance	100/0	090A	IV	Light Snow + Freezing Fog	Aluminum	-3	OAT	5	5
484	1	Quadruplet	Polar Guard Advance	100/0	090A	IV	Light Snow + Freezing Fog	Aluminum	-3	OAT	5	5
485	1	Octuplet	Polar Guard Advance	100/0	090A	IV	Light Snow + Freezing Fog	Aluminum	-3	OAT	5	5
486	1	Octuplet	Polar Guard Advance	100/0	090A	IV	Light Snow + Freezing Fog	Aluminum	-3	OAT	5	5
487	1	Octuplet	Polar Guard Advance	100/0	090A	IV	Light Snow + Freezing Fog	Aluminum	-3	OAT	5	5
488	1	Octuplet	Polar Guard Advance	100/0	090A	IV	Light Snow + Freezing Fog	Aluminum	-3	OAT	5	5
489	1	Duplicate	EG106	100/0	096A	IV	Light Snow + Freezing Fog	Aluminum	-3	OAT	5	5
490	1	Duplicate	EG106	100/0	096A	IV	Light Snow + Freezing Fog	Aluminum	-3	OAT	5	5
491	1	Quadruplet	EG106	100/0	096A	IV	Light Snow + Freezing Fog	Aluminum	-3	OAT	5	5
492	1	Quadruplet	EG106	100/0	096A	IV	Light Snow + Freezing Fog	Aluminum	-3	OAT	5	5
493	1	Octuplet	EG106	100/0	096A	IV	Light Snow + Freezing Fog	Aluminum	-3	OAT	5	5
494	1	Octuplet	EG106	100/0	096A	IV	Light Snow + Freezing Fog	Aluminum	-3	OAT	5	5
495	1	Octuplet	EG106	100/0	096A	IV	Light Snow + Freezing Fog	Aluminum	-3	OAT	5	5
496	1	Octuplet	EG106	100/0	096A	IV	Light Snow + Freezing Fog	Aluminum	-3	OAT	5	5
497	1	Duplicate	PG ADF Concentrate	33/67	097A	I	Light Snow + Freezing Fog	Aluminum	-3	20°C	10	5
498	1	Duplicate	PG ADF Concentrate	33/67	097A	I	Light Snow + Freezing Fog	Aluminum	-3	20°C	10	5
499	1	Quadruplet	PG ADF Concentrate	33/67	097A	I	Light Snow + Freezing Fog	Aluminum	-3	20°C	10	5
500	1	Quadruplet	PG ADF Concentrate	33/67	097A	I	Light Snow + Freezing Fog	Aluminum	-3	20°C	10	5
501	1	Octuplet	PG ADF Concentrate	33/67	097A	I	Light Snow + Freezing Fog	Aluminum	-3	20°C	10	5
502	1	Octuplet	PG ADF Concentrate	33/67	097A	I	Light Snow + Freezing Fog	Aluminum	-3	20°C	10	5
503	1	Octuplet	PG ADF Concentrate	33/67	097A	I	Light Snow + Freezing Fog	Aluminum	-3	20°C	10	5
504	1	Octuplet	PG ADF Concentrate	33/67	097A	I	Light Snow + Freezing Fog	Aluminum	-3	20°C	10	5
505	1	Duplicate	PG ADF Concentrate	33/67	097A	I	Light Snow + Freezing Fog	Composite	-3	20°C	10	5
506	1	Duplicate	PG ADF Concentrate	33/67	097A	I	Light Snow + Freezing Fog	Composite	-3	20°C	10	5
507	1	Quadruplet	PG ADF Concentrate	33/67	097A	I	Light Snow + Freezing Fog	Composite	-3	20°C	10	5
508	1	Quadruplet	PG ADF Concentrate	33/67	097A	I	Light Snow + Freezing Fog	Composite	-3	20°C	10	5
509	1	Octuplet	PG ADF Concentrate	33/67	097A	I	Light Snow + Freezing Fog	Composite	-3	20°C	10	5
510	1	Octuplet	PG ADF Concentrate	33/67	097A	I	Light Snow + Freezing Fog	Composite	-3	20°C	10	5
511	1	Octuplet	PG ADF Concentrate	33/67	097A	I	Light Snow + Freezing Fog	Composite	-3	20°C	10	5

Attachment 3: Proposed Test Plan for Testing Snow Mixed with Freezing Fog (cont'd)

Test No.	Priority	Test Type	Fluid	Dilution	APS Fluid Code	Fluid Type	Precipitation	Test Surface	Test Temp. (°C)	Fluid Temp. (°C)	Snow Rate (g/dm²/h)	Freezing Fog Rate (g/dm²/h)
512	1	Octuplet	PG ADF Concentrate	33/67	097A	I	Light Snow + Freezing Fog	Composite	-3	20°C	10	5
513	1	Duplicate	Safewing MP II FLIGHT	100/0	023A	II	Light Snow + Freezing Fog	Aluminum	-3	OAT	10	5
514	1	Duplicate	Safewing MP II FLIGHT	100/0	023A	II	Light Snow + Freezing Fog	Aluminum	-3	OAT	10	5
515	1	Quadruplet	Safewing MP II FLIGHT	100/0	023A	II	Light Snow + Freezing Fog	Aluminum	-3	OAT	10	5
516	1	Quadruplet	Safewing MP II FLIGHT	100/0	023A	II	Light Snow + Freezing Fog	Aluminum	-3	OAT	10	5
517	1	Octuplet	Safewing MP II FLIGHT	100/0	023A	II	Light Snow + Freezing Fog	Aluminum	-3	OAT	10	5
518	1	Octuplet	Safewing MP II FLIGHT	100/0	023A	II	Light Snow + Freezing Fog	Aluminum	-3	OAT	10	5
519	1	Octuplet	Safewing MP II FLIGHT	100/0	023A	II	Light Snow + Freezing Fog	Aluminum	-3	OAT	10	5
520	1	Octuplet	Safewing MP II FLIGHT	100/0	023A	II	Light Snow + Freezing Fog	Aluminum	-3	OAT	10	5
521	1	Calibration	AeroClear MAX	100/0	063A	III	Light Snow + Freezing Fog	Aluminum	-3	OAT	10	5
522	1	Calibration	AeroClear MAX	100/0	063A	III	Light Snow + Freezing Fog	Aluminum	-3	OAT	10	5
523	1	Calibration	AeroClear MAX	100/0	063A	III	Light Snow + Freezing Fog	Aluminum	-3	OAT	10	5
524	1	Calibration	AeroClear MAX	100/0	063A	III	Light Snow + Freezing Fog	Aluminum	-3	OAT	10	5
525	1	Calibration	AeroClear MAX	100/0	063A	III	Light Snow + Freezing Fog	Aluminum	-3	OAT	10	5
526	1	Calibration	AeroClear MAX	100/0	063A	III	Light Snow + Freezing Fog	Aluminum	-3	OAT	10	5
527	1	Calibration	AeroClear MAX	100/0	063A	III	Light Snow + Freezing Fog	Aluminum	-3	OAT	10	5
528	1	Calibration	AeroClear MAX	100/0	063A	III	Light Snow + Freezing Fog	Aluminum	-3	OAT	10	5
529	1	Calibration	AeroClear MAX	100/0	063A	III	Light Snow + Freezing Fog	Aluminum	-3	OAT	10	5
530	1	Calibration	AeroClear MAX	100/0	063A	III	Light Snow + Freezing Fog	Aluminum	-3	OAT	10	5
531	1	Calibration	AeroClear MAX	100/0	063A	III	Light Snow + Freezing Fog	Aluminum	-3	OAT	10	5
532	1	Calibration	AeroClear MAX	100/0	063A	III	Light Snow + Freezing Fog	Aluminum	-3	OAT	10	5
533	1	Duplicate	Polar Guard Advance	100/0	090A	IV	Light Snow + Freezing Fog	Aluminum	-3	OAT	10	5
534	1	Duplicate	Polar Guard Advance	100/0	090A	IV	Light Snow + Freezing Fog	Aluminum	-3	OAT	10	5
535	1	Quadruplet	Polar Guard Advance	100/0	090A	IV	Light Snow + Freezing Fog	Aluminum	-3	OAT	10	5
536	1	Quadruplet	Polar Guard Advance	100/0	090A	IV	Light Snow + Freezing Fog	Aluminum	-3	OAT	10	5
537	1	Octuplet	Polar Guard Advance	100/0	090A	IV	Light Snow + Freezing Fog	Aluminum	-3	OAT	10	5
538	1	Octuplet	Polar Guard Advance	100/0	090A	IV	Light Snow + Freezing Fog	Aluminum	-3	OAT	10	5
539	1	Octuplet	Polar Guard Advance	100/0	090A	IV	Light Snow + Freezing Fog	Aluminum	-3	OAT	10	5
540	1	Octuplet	Polar Guard Advance	100/0	090A	IV	Light Snow + Freezing Fog	Aluminum	-3	OAT	10	5
541	1	Duplicate	EG106	100/0	096A	IV	Light Snow + Freezing Fog	Aluminum	-3	OAT	10	5
542	1	Duplicate	EG106	100/0	096A	IV	Light Snow + Freezing Fog	Aluminum	-3	OAT	10	5
543	1	Quadruplet	EG106	100/0	096A	IV	Light Snow + Freezing Fog	Aluminum	-3	OAT	10	5

Attachment 3: Proposed Test Plan for Testing Snow Mixed with Freezing Fog (cont'd)

Test No.	Priority	Test Type	Fluid	Dilution	APS Fluid Code	Fluid Type	Precipitation	Test Surface	Test Temp. (°C)	Fluid Temp. (°C)	Snow Rate (g/dm²/h)	Freezing Fog Rate (g/dm²/h)
544	1	Quadruplet	EG106	100/0	096A	IV	Light Snow + Freezing Fog	Aluminum	-3	OAT	10	5
545	1	Octuplet	EG106	100/0	096A	IV	Light Snow + Freezing Fog	Aluminum	-3	OAT	10	5
546	1	Octuplet	EG106	100/0	096A	IV	Light Snow + Freezing Fog	Aluminum	-3	OAT	10	5
547	1	Octuplet	EG106	100/0	096A	IV	Light Snow + Freezing Fog	Aluminum	-3	OAT	10	5
548	1	Octuplet	EG106	100/0	096A	IV	Light Snow + Freezing Fog	Aluminum	-3	OAT	10	5
549	1	Duplicate	PG ADF Concentrate	33/67	097A	I	Moderate Snow + Freezing Fog	Aluminum	-3	20°C	20	5
550	1	Duplicate	PG ADF Concentrate	33/67	097A	I	Moderate Snow + Freezing Fog	Aluminum	-3	20°C	20	5
551	1	Quadruplet	PG ADF Concentrate	33/67	097A	I	Moderate Snow + Freezing Fog	Aluminum	-3	20°C	20	5
552	1	Quadruplet	PG ADF Concentrate	33/67	097A	I	Moderate Snow + Freezing Fog	Aluminum	-3	20°C	20	5
553	1	Octuplet	PG ADF Concentrate	33/67	097A	I	Moderate Snow + Freezing Fog	Aluminum	-3	20°C	20	5
554	1	Octuplet	PG ADF Concentrate	33/67	097A	I	Moderate Snow + Freezing Fog	Aluminum	-3	20°C	20	5
555	1	Octuplet	PG ADF Concentrate	33/67	097A	I	Moderate Snow + Freezing Fog	Aluminum	-3	20°C	20	5
556	1	Octuplet	PG ADF Concentrate	33/67	097A	I	Moderate Snow + Freezing Fog	Aluminum	-3	20°C	20	5
557	1	Duplicate	PG ADF Concentrate	33/67	097A	I	Moderate Snow + Freezing Fog	Composite	-3	20°C	20	5
558	1	Duplicate	PG ADF Concentrate	33/67	097A	I	Moderate Snow + Freezing Fog	Composite	-3	20°C	20	5
559	1	Quadruplet	PG ADF Concentrate	33/67	097A	I	Moderate Snow + Freezing Fog	Composite	-3	20°C	20	5
560	1	Quadruplet	PG ADF Concentrate	33/67	097A	I	Moderate Snow + Freezing Fog	Composite	-3	20°C	20	5
561	1	Octuplet	PG ADF Concentrate	33/67	097A	I	Moderate Snow + Freezing Fog	Composite	-3	20°C	20	5
562	1	Octuplet	PG ADF Concentrate	33/67	097A	I	Moderate Snow + Freezing Fog	Composite	-3	20°C	20	5
563	1	Octuplet	PG ADF Concentrate	33/67	097A	I	Moderate Snow + Freezing Fog	Composite	-3	20°C	20	5
564	1	Octuplet	PG ADF Concentrate	33/67	097A	I	Moderate Snow + Freezing Fog	Composite	-3	20°C	20	5
565	1	Duplicate	Safewing MP II FLIGHT	100/0	023A	II	Moderate Snow + Freezing Fog	Aluminum	-3	OAT	20	5
566	1	Duplicate	Safewing MP II FLIGHT	100/0	023A	II	Moderate Snow + Freezing Fog	Aluminum	-3	OAT	20	5
567	1	Quadruplet	Safewing MP II FLIGHT	100/0	023A	II	Moderate Snow + Freezing Fog	Aluminum	-3	OAT	20	5
568	1	Quadruplet	Safewing MP II FLIGHT	100/0	023A	II	Moderate Snow + Freezing Fog	Aluminum	-3	OAT	20	5
569	1	Octuplet	Safewing MP II FLIGHT	100/0	023A	II	Moderate Snow + Freezing Fog	Aluminum	-3	OAT	20	5
570	1	Octuplet	Safewing MP II FLIGHT	100/0	023A	II	Moderate Snow + Freezing Fog	Aluminum	-3	OAT	20	5
571	1	Octuplet	Safewing MP II FLIGHT	100/0	023A	II	Moderate Snow + Freezing Fog	Aluminum	-3	OAT	20	5
572	1	Octuplet	Safewing MP II FLIGHT	100/0	023A	II	Moderate Snow + Freezing Fog	Aluminum	-3	OAT	20	5
573	1	Calibration	AeroClear MAX	100/0	063A	III	Moderate Snow + Freezing Fog	Aluminum	-3	OAT	20	5
574	1	Calibration	AeroClear MAX	100/0	063A	III	Moderate Snow + Freezing Fog	Aluminum	-3	OAT	20	5
575	1	Calibration	AeroClear MAX	100/0	063A	III	Moderate Snow + Freezing Fog	Aluminum	-3	OAT	20	5

Attachment 3: Proposed Test Plan for Testing Snow Mixed with Freezing Fog (cont'd)

Test No.	Priority	Test Type	Fluid	Dilution	APS Fluid Code	Fluid Type	Precipitation	Test Surface	Test Temp. (°C)	Fluid Temp. (°C)	Snow Rate (g/dm²/h)	Freezing Fog Rate (g/dm²/h)
576	1	Calibration	AeroClear MAX	100/0	063A	III	Moderate Snow + Freezing Fog	Aluminum	-3	OAT	20	5
577	1	Calibration	AeroClear MAX	100/0	063A	III	Moderate Snow + Freezing Fog	Aluminum	-3	OAT	20	5
578	1	Calibration	AeroClear MAX	100/0	063A	III	Moderate Snow + Freezing Fog	Aluminum	-3	OAT	20	5
579	1	Calibration	AeroClear MAX	100/0	063A	III	Moderate Snow + Freezing Fog	Aluminum	-3	OAT	20	5
580	1	Calibration	AeroClear MAX	100/0	063A	III	Moderate Snow + Freezing Fog	Aluminum	-3	OAT	20	5
581	1	Calibration	AeroClear MAX	100/0	063A	III	Moderate Snow + Freezing Fog	Aluminum	-3	OAT	20	5
582	1	Calibration	AeroClear MAX	100/0	063A	III	Moderate Snow + Freezing Fog	Aluminum	-3	OAT	20	5
583	1	Calibration	AeroClear MAX	100/0	063A	III	Moderate Snow + Freezing Fog	Aluminum	-3	OAT	20	5
584	1	Calibration	AeroClear MAX	100/0	063A	III	Moderate Snow + Freezing Fog	Aluminum	-3	OAT	20	5
585	1	Duplicate	Polar Guard Advance	100/0	090A	IV	Moderate Snow + Freezing Fog	Aluminum	-3	OAT	20	5
586	1	Duplicate	Polar Guard Advance	100/0	090A	IV	Moderate Snow + Freezing Fog	Aluminum	-3	OAT	20	5
587	1	Quadruplet	Polar Guard Advance	100/0	090A	IV	Moderate Snow + Freezing Fog	Aluminum	-3	OAT	20	5
588	1	Quadruplet	Polar Guard Advance	100/0	090A	IV	Moderate Snow + Freezing Fog	Aluminum	-3	OAT	20	5
589	1	Octuplet	Polar Guard Advance	100/0	090A	IV	Moderate Snow + Freezing Fog	Aluminum	-3	OAT	20	5
590	1	Octuplet	Polar Guard Advance	100/0	090A	IV	Moderate Snow + Freezing Fog	Aluminum	-3	OAT	20	5
591	1	Octuplet	Polar Guard Advance	100/0	090A	IV	Moderate Snow + Freezing Fog	Aluminum	-3	OAT	20	5
592	1	Octuplet	Polar Guard Advance	100/0	090A	IV	Moderate Snow + Freezing Fog	Aluminum	-3	OAT	20	5
593	1	Duplicate	EG106	100/0	096A	IV	Moderate Snow + Freezing Fog	Aluminum	-3	OAT	20	5
594	1	Duplicate	EG106	100/0	096A	IV	Moderate Snow + Freezing Fog	Aluminum	-3	OAT	20	5
595	1	Quadruplet	EG106	100/0	096A	IV	Moderate Snow + Freezing Fog	Aluminum	-3	OAT	20	5
596	1	Quadruplet	EG106	100/0	096A	IV	Moderate Snow + Freezing Fog	Aluminum	-3	OAT	20	5
597	1	Octuplet	EG106	100/0	096A	IV	Moderate Snow + Freezing Fog	Aluminum	-3	OAT	20	5
598	1	Octuplet	EG106	100/0	096A	IV	Moderate Snow + Freezing Fog	Aluminum	-3	OAT	20	5
599	1	Octuplet	EG106	100/0	096A	IV	Moderate Snow + Freezing Fog	Aluminum	-3	OAT	20	5
600	1	Octuplet	EG106	100/0	096A	IV	Moderate Snow + Freezing Fog	Aluminum	-3	OAT	20	5
601	1	Duplicate	PG ADF Concentrate	33/67	097A	I	Moderate Snow + Freezing Fog	Aluminum	-3	20°C	25	5
602	1	Duplicate	PG ADF Concentrate	33/67	097A	I	Moderate Snow + Freezing Fog	Aluminum	-3	20°C	25	5
603	1	Quadruplet	PG ADF Concentrate	33/67	097A	I	Moderate Snow + Freezing Fog	Aluminum	-3	20°C	25	5
604	1	Quadruplet	PG ADF Concentrate	33/67	097A	I	Moderate Snow + Freezing Fog	Aluminum	-3	20°C	25	5
605	1	Octuplet	PG ADF Concentrate	33/67	097A	I	Moderate Snow + Freezing Fog	Aluminum	-3	20°C	25	5
606	1	Octuplet	PG ADF Concentrate	33/67	097A	I	Moderate Snow + Freezing Fog	Aluminum	-3	20°C	25	5
607	1	Octuplet	PG ADF Concentrate	33/67	097A	I	Moderate Snow + Freezing Fog	Aluminum	-3	20°C	25	5

Attachment 3: Proposed Test Plan for Testing Snow Mixed with Freezing Fog (cont'd)

Test No.	Priority	Test Type	Fluid	Dilution	APS Fluid Code	Fluid Type	Precipitation	Test Surface	Test Temp. (°C)	Fluid Temp. (°C)	Snow Rate (g/dm²/h)	Freezing Fog Rate (g/dm²/h)
608	1	Octuplet	PG ADF Concentrate	33/67	097A	I	Moderate Snow + Freezing Fog	Aluminum	-3	20°C	25	5
609	1	Duplicate	PG ADF Concentrate	33/67	097A	I	Moderate Snow + Freezing Fog	Composite	-3	20°C	25	5
610	1	Duplicate	PG ADF Concentrate	33/67	097A	I	Moderate Snow + Freezing Fog	Composite	-3	20°C	25	5
611	1	Quadruplet	PG ADF Concentrate	33/67	097A	I	Moderate Snow + Freezing Fog	Composite	-3	20°C	25	5
612	1	Quadruplet	PG ADF Concentrate	33/67	097A	I	Moderate Snow + Freezing Fog	Composite	-3	20°C	25	5
613	1	Octuplet	PG ADF Concentrate	33/67	097A	I	Moderate Snow + Freezing Fog	Composite	-3	20°C	25	5
614	1	Octuplet	PG ADF Concentrate	33/67	097A	I	Moderate Snow + Freezing Fog	Composite	-3	20°C	25	5
615	1	Octuplet	PG ADF Concentrate	33/67	097A	I	Moderate Snow + Freezing Fog	Composite	-3	20°C	25	5
616	1	Octuplet	PG ADF Concentrate	33/67	097A	I	Moderate Snow + Freezing Fog	Composite	-3	20°C	25	5
617	1	Duplicate	Safewing MP II FLIGHT	100/0	023A	II	Moderate Snow + Freezing Fog	Aluminum	-3	OAT	25	5
618	1	Duplicate	Safewing MP II FLIGHT	100/0	023A	II	Moderate Snow + Freezing Fog	Aluminum	-3	OAT	25	5
619	1	Quadruplet	Safewing MP II FLIGHT	100/0	023A	II	Moderate Snow + Freezing Fog	Aluminum	-3	OAT	25	5
620	1	Quadruplet	Safewing MP II FLIGHT	100/0	023A	II	Moderate Snow + Freezing Fog	Aluminum	-3	OAT	25	5
621	1	Octuplet	Safewing MP II FLIGHT	100/0	023A	II	Moderate Snow + Freezing Fog	Aluminum	-3	OAT	25	5
622	1	Octuplet	Safewing MP II FLIGHT	100/0	023A	II	Moderate Snow + Freezing Fog	Aluminum	-3	OAT	25	5
623	1	Octuplet	Safewing MP II FLIGHT	100/0	023A	II	Moderate Snow + Freezing Fog	Aluminum	-3	OAT	25	5
624	1	Octuplet	Safewing MP II FLIGHT	100/0	023A	II	Moderate Snow + Freezing Fog	Aluminum	-3	OAT	25	5
625	1	Calibration	AeroClear MAX	100/0	063A	III	Moderate Snow + Freezing Fog	Aluminum	-3	OAT	25	5
626	1	Calibration	AeroClear MAX	100/0	063A	III	Moderate Snow + Freezing Fog	Aluminum	-3	OAT	25	5
627	1	Calibration	AeroClear MAX	100/0	063A	III	Moderate Snow + Freezing Fog	Aluminum	-3	OAT	25	5
628	1	Calibration	AeroClear MAX	100/0	063A	III	Moderate Snow + Freezing Fog	Aluminum	-3	OAT	25	5
629	1	Calibration	AeroClear MAX	100/0	063A	III	Moderate Snow + Freezing Fog	Aluminum	-3	OAT	25	5
630	1	Calibration	AeroClear MAX	100/0	063A	III	Moderate Snow + Freezing Fog	Aluminum	-3	OAT	25	5
631	1	Calibration	AeroClear MAX	100/0	063A	III	Moderate Snow + Freezing Fog	Aluminum	-3	OAT	25	5
632	1	Calibration	AeroClear MAX	100/0	063A	III	Moderate Snow + Freezing Fog	Aluminum	-3	OAT	25	5
633	1	Calibration	AeroClear MAX	100/0	063A	III	Moderate Snow + Freezing Fog	Aluminum	-3	OAT	25	5
634	1	Calibration	AeroClear MAX	100/0	063A	III	Moderate Snow + Freezing Fog	Aluminum	-3	OAT	25	5
635	1	Calibration	AeroClear MAX	100/0	063A	III	Moderate Snow + Freezing Fog	Aluminum	-3	OAT	25	5
636	1	Calibration	AeroClear MAX	100/0	063A	III	Moderate Snow + Freezing Fog	Aluminum	-3	OAT	25	5
637	1	Duplicate	Polar Guard Advance	100/0	090A	IV	Moderate Snow + Freezing Fog	Aluminum	-3	OAT	25	5
638	1	Duplicate	Polar Guard Advance	100/0	090A	IV	Moderate Snow + Freezing Fog	Aluminum	-3	OAT	25	5
639	1	Quadruplet	Polar Guard Advance	100/0	090A	IV	Moderate Snow + Freezing Fog	Aluminum	-3	OAT	25	5

Attachment 3: Proposed Test Plan for Testing Snow Mixed with Freezing Fog (cont'd)

Test No.	Priority	Test Type	Fluid	Dilution	APS Fluid Code	Fluid Type	Precipitation	Test Surface	Test Temp. (°C)	Fluid Temp. (°C)	Snow Rate (g/dm²/h)	Freezing Fog Rate (g/dm²/h)
640	1	Quadruplet	Polar Guard Advance	100/0	090A	IV	Moderate Snow + Freezing Fog	Aluminum	-3	OAT	25	5
641	1	Octuplet	Polar Guard Advance	100/0	090A	IV	Moderate Snow + Freezing Fog	Aluminum	-3	OAT	25	5
642	1	Octuplet	Polar Guard Advance	100/0	090A	IV	Moderate Snow + Freezing Fog	Aluminum	-3	OAT	25	5
643	1	Octuplet	Polar Guard Advance	100/0	090A	IV	Moderate Snow + Freezing Fog	Aluminum	-3	OAT	25	5
644	1	Octuplet	Polar Guard Advance	100/0	090A	IV	Moderate Snow + Freezing Fog	Aluminum	-3	OAT	25	5
645	1	Duplicate	EG106	100/0	096A	IV	Moderate Snow + Freezing Fog	Aluminum	-3	OAT	25	5
646	1	Duplicate	EG106	100/0	096A	IV	Moderate Snow + Freezing Fog	Aluminum	-3	OAT	25	5
647	1	Quadruplet	EG106	100/0	096A	IV	Moderate Snow + Freezing Fog	Aluminum	-3	OAT	25	5
648	1	Quadruplet	EG106	100/0	096A	IV	Moderate Snow + Freezing Fog	Aluminum	-3	OAT	25	5
649	1	Octuplet	EG106	100/0	096A	IV	Moderate Snow + Freezing Fog	Aluminum	-3	OAT	25	5
650	1	Octuplet	EG106	100/0	096A	IV	Moderate Snow + Freezing Fog	Aluminum	-3	OAT	25	5
651	1	Octuplet	EG106	100/0	096A	IV	Moderate Snow + Freezing Fog	Aluminum	-3	OAT	25	5
652	1	Octuplet	EG106	100/0	096A	IV	Moderate Snow + Freezing Fog	Aluminum	-3	OAT	25	5
653	1	Duplicate	PG ADF Concentrate	46/54	097A	I	Light Snow + Freezing Fog	Aluminum	-14	20°C	5	5
654	1	Duplicate	PG ADF Concentrate	46/54	097A	I	Light Snow + Freezing Fog	Aluminum	-14	20°C	5	5
655	1	Quadruplet	PG ADF Concentrate	46/54	097A	I	Light Snow + Freezing Fog	Aluminum	-14	20°C	5	5
656	1	Quadruplet	PG ADF Concentrate	46/54	097A	I	Light Snow + Freezing Fog	Aluminum	-14	20°C	5	5
657	1	Octuplet	PG ADF Concentrate	46/54	097A	I	Light Snow + Freezing Fog	Aluminum	-14	20°C	5	5
658	1	Octuplet	PG ADF Concentrate	46/54	097A	I	Light Snow + Freezing Fog	Aluminum	-14	20°C	5	5
659	1	Octuplet	PG ADF Concentrate	46/54	097A	I	Light Snow + Freezing Fog	Aluminum	-14	20°C	5	5
660	1	Octuplet	PG ADF Concentrate	46/54	097A	I	Light Snow + Freezing Fog	Aluminum	-14	20°C	5	5
661	1	Duplicate	PG ADF Concentrate	46/54	097A	I	Light Snow + Freezing Fog	Composite	-14	20°C	5	5
662	1	Duplicate	PG ADF Concentrate	46/54	097A	I	Light Snow + Freezing Fog	Composite	-14	20°C	5	5
663	1	Quadruplet	PG ADF Concentrate	46/54	097A	I	Light Snow + Freezing Fog	Composite	-14	20°C	5	5
664	1	Quadruplet	PG ADF Concentrate	46/54	097A	I	Light Snow + Freezing Fog	Composite	-14	20°C	5	5
665	1	Octuplet	PG ADF Concentrate	46/54	097A	I	Light Snow + Freezing Fog	Composite	-14	20°C	5	5
666	1	Octuplet	PG ADF Concentrate	46/54	097A	I	Light Snow + Freezing Fog	Composite	-14	20°C	5	5
667	1	Octuplet	PG ADF Concentrate	46/54	097A	I	Light Snow + Freezing Fog	Composite	-14	20°C	5	5
668	1	Octuplet	PG ADF Concentrate	46/54	097A	I	Light Snow + Freezing Fog	Composite	-14	20°C	5	5
669	1	Duplicate	Safewing MP II FLIGHT	100/0	023A	II	Light Snow + Freezing Fog	Aluminum	-14	OAT	5	5
670	1	Duplicate	Safewing MP II FLIGHT	100/0	023A	II	Light Snow + Freezing Fog	Aluminum	-14	OAT	5	5
671	1	Quadruplet	Safewing MP II FLIGHT	100/0	023A	II	Light Snow + Freezing Fog	Aluminum	-14	OAT	5	5

Attachment 3: Proposed Test Plan for Testing Snow Mixed with Freezing Fog (cont'd)

Test No.	Priority	Test Type	Fluid	Dilution	APS Fluid Code	Fluid Type	Precipitation	Test Surface	Test Temp. (°C)	Fluid Temp. (°C)	Snow Rate (g/dm²/h)	Freezing Fog Rate (g/dm²/h)
672	1	Quadruplet	Safewing MP II FLIGHT	100/0	023A	II	Light Snow + Freezing Fog	Aluminum	-14	OAT	5	5
673	1	Octuplet	Safewing MP II FLIGHT	100/0	023A	II	Light Snow + Freezing Fog	Aluminum	-14	OAT	5	5
674	1	Octuplet	Safewing MP II FLIGHT	100/0	023A	II	Light Snow + Freezing Fog	Aluminum	-14	OAT	5	5
675	1	Octuplet	Safewing MP II FLIGHT	100/0	023A	II	Light Snow + Freezing Fog	Aluminum	-14	OAT	5	5
676	1	Octuplet	Safewing MP II FLIGHT	100/0	023A	II	Light Snow + Freezing Fog	Aluminum	-14	OAT	5	5
677	1	Duplicate	AeroClear MAX	100/0	067A	III	Light Snow + Freezing Fog	Aluminum	-14	OAT	5	5
678	1	Duplicate	AeroClear MAX	100/0	067A	III	Light Snow + Freezing Fog	Aluminum	-14	OAT	5	5
679	1	Quadruplet	AeroClear MAX	100/0	067A	III	Light Snow + Freezing Fog	Aluminum	-14	OAT	5	5
680	1	Quadruplet	AeroClear MAX	100/0	067A	III	Light Snow + Freezing Fog	Aluminum	-14	OAT	5	5
681	1	Octuplet	AeroClear MAX	100/0	067A	III	Light Snow + Freezing Fog	Aluminum	-14	OAT	5	5
682	1	Octuplet	AeroClear MAX	100/0	067A	III	Light Snow + Freezing Fog	Aluminum	-14	OAT	5	5
683	1	Octuplet	AeroClear MAX	100/0	067A	III	Light Snow + Freezing Fog	Aluminum	-14	OAT	5	5
684	1	Octuplet	AeroClear MAX	100/0	067A	III	Light Snow + Freezing Fog	Aluminum	-14	OAT	5	5
685	1	Duplicate	Polar Guard Advance	100/0	090A	IV	Light Snow + Freezing Fog	Aluminum	-14	OAT	5	5
686	1	Duplicate	Polar Guard Advance	100/0	090A	IV	Light Snow + Freezing Fog	Aluminum	-14	OAT	5	5
687	1	Quadruplet	Polar Guard Advance	100/0	090A	IV	Light Snow + Freezing Fog	Aluminum	-14	OAT	5	5
688	1	Quadruplet	Polar Guard Advance	100/0	090A	IV	Light Snow + Freezing Fog	Aluminum	-14	OAT	5	5
689	1	Octuplet	Polar Guard Advance	100/0	090A	IV	Light Snow + Freezing Fog	Aluminum	-14	OAT	5	5
690	1	Octuplet	Polar Guard Advance	100/0	090A	IV	Light Snow + Freezing Fog	Aluminum	-14	OAT	5	5
691	1	Octuplet	Polar Guard Advance	100/0	090A	IV	Light Snow + Freezing Fog	Aluminum	-14	OAT	5	5
692	1	Octuplet	Polar Guard Advance	100/0	090A	IV	Light Snow + Freezing Fog	Aluminum	-14	OAT	5	5
693	1	Duplicate	EG106	100/0	096A	IV	Light Snow + Freezing Fog	Aluminum	-14	OAT	5	5
694	1	Duplicate	EG106	100/0	096A	IV	Light Snow + Freezing Fog	Aluminum	-14	OAT	5	5
695	1	Quadruplet	EG106	100/0	096A	IV	Light Snow + Freezing Fog	Aluminum	-14	OAT	5	5
696	1	Quadruplet	EG106	100/0	096A	IV	Light Snow + Freezing Fog	Aluminum	-14	OAT	5	5
697	1	Octuplet	EG106	100/0	096A	IV	Light Snow + Freezing Fog	Aluminum	-14	OAT	5	5
698	1	Octuplet	EG106	100/0	096A	IV	Light Snow + Freezing Fog	Aluminum	-14	OAT	5	5
699	1	Octuplet	EG106	100/0	096A	IV	Light Snow + Freezing Fog	Aluminum	-14	OAT	5	5
700	1	Octuplet	EG106	100/0	096A	IV	Light Snow + Freezing Fog	Aluminum	-14	OAT	5	5
701	1	Duplicate	PG ADF Concentrate	46/54	097A	I	Light Snow + Freezing Fog	Aluminum	-14	20°C	10	5
702	1	Duplicate	PG ADF Concentrate	46/54	097A	I	Light Snow + Freezing Fog	Aluminum	-14	20°C	10	5
703	1	Quadruplet	PG ADF Concentrate	46/54	097A	I	Light Snow + Freezing Fog	Aluminum	-14	20°C	10	5

Attachment 3: Proposed Test Plan for Testing Snow Mixed with Freezing Fog (cont'd)

Test No.	Priority	Test Type	Fluid	Dilution	APS Fluid Code	Fluid Type	Precipitation	Test Surface	Test Temp. (°C)	Fluid Temp. (°C)	Snow Rate (g/dm²/h)	Freezing Fog Rate (g/dm²/h)
704	1	Quadruplet	PG ADF Concentrate	46/54	097A	I	Light Snow + Freezing Fog	Aluminum	-14	20°C	10	5
705	1	Octuplet	PG ADF Concentrate	46/54	097A	I	Light Snow + Freezing Fog	Aluminum	-14	20°C	10	5
706	1	Octuplet	PG ADF Concentrate	46/54	097A	I	Light Snow + Freezing Fog	Aluminum	-14	20°C	10	5
707	1	Octuplet	PG ADF Concentrate	46/54	097A	I	Light Snow + Freezing Fog	Aluminum	-14	20°C	10	5
708	1	Octuplet	PG ADF Concentrate	46/54	097A	I	Light Snow + Freezing Fog	Aluminum	-14	20°C	10	5
709	1	Duplicate	PG ADF Concentrate	46/54	097A	I	Light Snow + Freezing Fog	Composite	-14	20°C	10	5
710	1	Duplicate	PG ADF Concentrate	46/54	097A	I	Light Snow + Freezing Fog	Composite	-14	20°C	10	5
711	1	Quadruplet	PG ADF Concentrate	46/54	097A	I	Light Snow + Freezing Fog	Composite	-14	20°C	10	5
712	1	Quadruplet	PG ADF Concentrate	46/54	097A	I	Light Snow + Freezing Fog	Composite	-14	20°C	10	5
713	1	Octuplet	PG ADF Concentrate	46/54	097A	I	Light Snow + Freezing Fog	Composite	-14	20°C	10	5
714	1	Octuplet	PG ADF Concentrate	46/54	097A	I	Light Snow + Freezing Fog	Composite	-14	20°C	10	5
715	1	Octuplet	PG ADF Concentrate	46/54	097A	I	Light Snow + Freezing Fog	Composite	-14	20°C	10	5
716	1	Octuplet	PG ADF Concentrate	46/54	097A	I	Light Snow + Freezing Fog	Composite	-14	20°C	10	5
717	1	Duplicate	Safewing MP II FLIGHT	100/0	023A	II	Light Snow + Freezing Fog	Aluminum	-14	OAT	10	5
718	1	Duplicate	Safewing MP II FLIGHT	100/0	023A	II	Light Snow + Freezing Fog	Aluminum	-14	OAT	10	5
719	1	Quadruplet	Safewing MP II FLIGHT	100/0	023A	II	Light Snow + Freezing Fog	Aluminum	-14	OAT	10	5
720	1	Quadruplet	Safewing MP II FLIGHT	100/0	023A	II	Light Snow + Freezing Fog	Aluminum	-14	OAT	10	5
721	1	Octuplet	Safewing MP II FLIGHT	100/0	023A	II	Light Snow + Freezing Fog	Aluminum	-14	OAT	10	5
722	1	Octuplet	Safewing MP II FLIGHT	100/0	023A	II	Light Snow + Freezing Fog	Aluminum	-14	OAT	10	5
723	1	Octuplet	Safewing MP II FLIGHT	100/0	023A	II	Light Snow + Freezing Fog	Aluminum	-14	OAT	10	5
724	1	Octuplet	Safewing MP II FLIGHT	100/0	023A	II	Light Snow + Freezing Fog	Aluminum	-14	OAT	10	5
725	1	Duplicate	AeroClear MAX	100/0	067A	III	Light Snow + Freezing Fog	Aluminum	-14	OAT	10	5
726	1	Duplicate	AeroClear MAX	100/0	067A	III	Light Snow + Freezing Fog	Aluminum	-14	OAT	10	5
727	1	Quadruplet	AeroClear MAX	100/0	067A	III	Light Snow + Freezing Fog	Aluminum	-14	OAT	10	5
728	1	Quadruplet	AeroClear MAX	100/0	067A	III	Light Snow + Freezing Fog	Aluminum	-14	OAT	10	5
729	1	Octuplet	AeroClear MAX	100/0	067A	III	Light Snow + Freezing Fog	Aluminum	-14	OAT	10	5
730	1	Octuplet	AeroClear MAX	100/0	067A	III	Light Snow + Freezing Fog	Aluminum	-14	OAT	10	5
731	1	Octuplet	AeroClear MAX	100/0	067A	III	Light Snow + Freezing Fog	Aluminum	-14	OAT	10	5
732	1	Octuplet	AeroClear MAX	100/0	067A	III	Light Snow + Freezing Fog	Aluminum	-14	OAT	10	5
733	1	Duplicate	Polar Guard Advance	100/0	090A	IV	Light Snow + Freezing Fog	Aluminum	-14	OAT	10	5
734	1	Duplicate	Polar Guard Advance	100/0	090A	IV	Light Snow + Freezing Fog	Aluminum	-14	OAT	10	5
735	1	Quadruplet	Polar Guard Advance	100/0	090A	IV	Light Snow + Freezing Fog	Aluminum	-14	OAT	10	5

Attachment 3: Proposed Test Plan for Testing Snow Mixed with Freezing Fog (cont'd)

Test No.	Priority	Test Type	Fluid	Dilution	APS Fluid Code	Fluid Type	Precipitation	Test Surface	Test Temp. (°C)	Fluid Temp. (°C)	Snow Rate (g/dm²/h)	Freezing Fog Rate (g/dm²/h)
736	1	Quadruplet	Polar Guard Advance	100/0	090A	IV	Light Snow + Freezing Fog	Aluminum	-14	OAT	10	5
737	1	Octuplet	Polar Guard Advance	100/0	090A	IV	Light Snow + Freezing Fog	Aluminum	-14	OAT	10	5
738	1	Octuplet	Polar Guard Advance	100/0	090A	IV	Light Snow + Freezing Fog	Aluminum	-14	OAT	10	5
739	1	Octuplet	Polar Guard Advance	100/0	090A	IV	Light Snow + Freezing Fog	Aluminum	-14	OAT	10	5
740	1	Octuplet	Polar Guard Advance	100/0	090A	IV	Light Snow + Freezing Fog	Aluminum	-14	OAT	10	5
741	1	Duplicate	EG106	100/0	096A	IV	Light Snow + Freezing Fog	Aluminum	-14	OAT	10	5
742	1	Duplicate	EG106	100/0	096A	IV	Light Snow + Freezing Fog	Aluminum	-14	OAT	10	5
743	1	Quadruplet	EG106	100/0	096A	IV	Light Snow + Freezing Fog	Aluminum	-14	OAT	10	5
744	1	Quadruplet	EG106	100/0	096A	IV	Light Snow + Freezing Fog	Aluminum	-14	OAT	10	5
745	1	Octuplet	EG106	100/0	096A	IV	Light Snow + Freezing Fog	Aluminum	-14	OAT	10	5
746	1	Octuplet	EG106	100/0	096A	IV	Light Snow + Freezing Fog	Aluminum	-14	OAT	10	5
747	1	Octuplet	EG106	100/0	096A	IV	Light Snow + Freezing Fog	Aluminum	-14	OAT	10	5
748	1	Octuplet	EG106	100/0	096A	IV	Light Snow + Freezing Fog	Aluminum	-14	OAT	10	5
749	1	Duplicate	PG ADF Concentrate	46/54	097A	I	Moderate Snow + Freezing Fog	Aluminum	-14	20°C	20	5
750	1	Duplicate	PG ADF Concentrate	46/54	097A	I	Moderate Snow + Freezing Fog	Aluminum	-14	20°C	20	5
751	1	Quadruplet	PG ADF Concentrate	46/54	097A	I	Moderate Snow + Freezing Fog	Aluminum	-14	20°C	20	5
752	1	Quadruplet	PG ADF Concentrate	46/54	097A	I	Moderate Snow + Freezing Fog	Aluminum	-14	20°C	20	5
753	1	Octuplet	PG ADF Concentrate	46/54	097A	I	Moderate Snow + Freezing Fog	Aluminum	-14	20°C	20	5
754	1	Octuplet	PG ADF Concentrate	46/54	097A	I	Moderate Snow + Freezing Fog	Aluminum	-14	20°C	20	5
755	1	Octuplet	PG ADF Concentrate	46/54	097A	I	Moderate Snow + Freezing Fog	Aluminum	-14	20°C	20	5
756	1	Octuplet	PG ADF Concentrate	46/54	097A	I	Moderate Snow + Freezing Fog	Aluminum	-14	20°C	20	5
757	1	Duplicate	PG ADF Concentrate	46/54	097A	I	Moderate Snow + Freezing Fog	Composite	-14	20°C	20	5
758	1	Duplicate	PG ADF Concentrate	46/54	097A	I	Moderate Snow + Freezing Fog	Composite	-14	20°C	20	5
759	1	Quadruplet	PG ADF Concentrate	46/54	097A	I	Moderate Snow + Freezing Fog	Composite	-14	20°C	20	5
760	1	Quadruplet	PG ADF Concentrate	46/54	097A	I	Moderate Snow + Freezing Fog	Composite	-14	20°C	20	5
761	1	Octuplet	PG ADF Concentrate	46/54	097A	I	Moderate Snow + Freezing Fog	Composite	-14	20°C	20	5
762	1	Octuplet	PG ADF Concentrate	46/54	097A	I	Moderate Snow + Freezing Fog	Composite	-14	20°C	20	5
763	1	Octuplet	PG ADF Concentrate	46/54	097A	I	Moderate Snow + Freezing Fog	Composite	-14	20°C	20	5
764	1	Octuplet	PG ADF Concentrate	46/54	097A	I	Moderate Snow + Freezing Fog	Composite	-14	20°C	20	5
765	1	Duplicate	Safewing MP II FLIGHT	100/0	023A	II	Moderate Snow + Freezing Fog	Aluminum	-14	OAT	20	5
766	1	Duplicate	Safewing MP II FLIGHT	100/0	023A	II	Moderate Snow + Freezing Fog	Aluminum	-14	OAT	20	5
767	1	Quadruplet	Safewing MP II FLIGHT	100/0	023A	II	Moderate Snow + Freezing Fog	Aluminum	-14	OAT	20	5

Attachment 3: Proposed Test Plan for Testing Snow Mixed with Freezing Fog (cont'd)

Test No.	Priority	Test Type	Fluid	Dilution	APS Fluid Code	Fluid Type	Precipitation	Test Surface	Test Temp. (°C)	Fluid Temp. (°C)	Snow Rate (g/dm²/h)	Freezing Fog Rate (g/dm²/h)
768	1	Quadruplet	Safewing MP II FLIGHT	100/0	023A	II	Moderate Snow + Freezing Fog	Aluminum	-14	OAT	20	5
769	1	Octuplet	Safewing MP II FLIGHT	100/0	023A	II	Moderate Snow + Freezing Fog	Aluminum	-14	OAT	20	5
770	1	Octuplet	Safewing MP II FLIGHT	100/0	023A	II	Moderate Snow + Freezing Fog	Aluminum	-14	OAT	20	5
771	1	Octuplet	Safewing MP II FLIGHT	100/0	023A	II	Moderate Snow + Freezing Fog	Aluminum	-14	OAT	20	5
772	1	Octuplet	Safewing MP II FLIGHT	100/0	023A	II	Moderate Snow + Freezing Fog	Aluminum	-14	OAT	20	5
773	1	Duplicate	AeroClear MAX	100/0	067A	III	Moderate Snow + Freezing Fog	Aluminum	-14	OAT	20	5
774	1	Duplicate	AeroClear MAX	100/0	067A	III	Moderate Snow + Freezing Fog	Aluminum	-14	OAT	20	5
775	1	Quadruplet	AeroClear MAX	100/0	067A	III	Moderate Snow + Freezing Fog	Aluminum	-14	OAT	20	5
776	1	Quadruplet	AeroClear MAX	100/0	067A	III	Moderate Snow + Freezing Fog	Aluminum	-14	OAT	20	5
777	1	Octuplet	AeroClear MAX	100/0	067A	III	Moderate Snow + Freezing Fog	Aluminum	-14	OAT	20	5
778	1	Octuplet	AeroClear MAX	100/0	067A	III	Moderate Snow + Freezing Fog	Aluminum	-14	OAT	20	5
779	1	Octuplet	AeroClear MAX	100/0	067A	III	Moderate Snow + Freezing Fog	Aluminum	-14	OAT	20	5
780	1	Octuplet	AeroClear MAX	100/0	067A	III	Moderate Snow + Freezing Fog	Aluminum	-14	OAT	20	5
781	1	Duplicate	Polar Guard Advance	100/0	090A	IV	Moderate Snow + Freezing Fog	Aluminum	-14	OAT	20	5
782	1	Duplicate	Polar Guard Advance	100/0	090A	IV	Moderate Snow + Freezing Fog	Aluminum	-14	OAT	20	5
783	1	Quadruplet	Polar Guard Advance	100/0	090A	IV	Moderate Snow + Freezing Fog	Aluminum	-14	OAT	20	5
784	1	Quadruplet	Polar Guard Advance	100/0	090A	IV	Moderate Snow + Freezing Fog	Aluminum	-14	OAT	20	5
785	1	Octuplet	Polar Guard Advance	100/0	090A	IV	Moderate Snow + Freezing Fog	Aluminum	-14	OAT	20	5
786	1	Octuplet	Polar Guard Advance	100/0	090A	IV	Moderate Snow + Freezing Fog	Aluminum	-14	OAT	20	5
787	1	Octuplet	Polar Guard Advance	100/0	090A	IV	Moderate Snow + Freezing Fog	Aluminum	-14	OAT	20	5
788	1	Octuplet	Polar Guard Advance	100/0	090A	IV	Moderate Snow + Freezing Fog	Aluminum	-14	OAT	20	5
789	1	Duplicate	EG106	100/0	096A	IV	Moderate Snow + Freezing Fog	Aluminum	-14	OAT	20	5
790	1	Duplicate	EG106	100/0	096A	IV	Moderate Snow + Freezing Fog	Aluminum	-14	OAT	20	5
791	1	Quadruplet	EG106	100/0	096A	IV	Moderate Snow + Freezing Fog	Aluminum	-14	OAT	20	5
792	1	Quadruplet	EG106	100/0	096A	IV	Moderate Snow + Freezing Fog	Aluminum	-14	OAT	20	5
793	1	Octuplet	EG106	100/0	096A	IV	Moderate Snow + Freezing Fog	Aluminum	-14	OAT	20	5
794	1	Octuplet	EG106	100/0	096A	IV	Moderate Snow + Freezing Fog	Aluminum	-14	OAT	20	5
795	1	Octuplet	EG106	100/0	096A	IV	Moderate Snow + Freezing Fog	Aluminum	-14	OAT	20	5
796	1	Octuplet	EG106	100/0	096A	IV	Moderate Snow + Freezing Fog	Aluminum	-14	OAT	20	5
797	1	Duplicate	PG ADF Concentrate	46/54	097A	I	Moderate Snow + Freezing Fog	Aluminum	-14	20°C	25	5
798	1	Duplicate	PG ADF Concentrate	46/54	097A	I	Moderate Snow + Freezing Fog	Aluminum	-14	20°C	25	5
799	1	Quadruplet	PG ADF Concentrate	46/54	097A	I	Moderate Snow + Freezing Fog	Aluminum	-14	20°C	25	5

Attachment 3: Proposed Test Plan for Testing Snow Mixed with Freezing Fog (cont'd)

Test No.	Priority	Test Type	Fluid	Dilution	APS Fluid Code	Fluid Type	Precipitation	Test Surface	Test Temp. (°C)	Fluid Temp. (°C)	Snow Rate (g/dm²/h)	Freezing Fog Rate (g/dm²/h)
800	1	Quadruplet	PG ADF Concentrate	46/54	097A	I	Moderate Snow + Freezing Fog	Aluminum	-14	20°C	25	5
801	1	Octuplet	PG ADF Concentrate	46/54	097A	I	Moderate Snow + Freezing Fog	Aluminum	-14	20°C	25	5
802	1	Octuplet	PG ADF Concentrate	46/54	097A	I	Moderate Snow + Freezing Fog	Aluminum	-14	20°C	25	5
803	1	Octuplet	PG ADF Concentrate	46/54	097A	I	Moderate Snow + Freezing Fog	Aluminum	-14	20°C	25	5
804	1	Octuplet	PG ADF Concentrate	46/54	097A	I	Moderate Snow + Freezing Fog	Aluminum	-14	20°C	25	5
805	1	Duplicate	PG ADF Concentrate	46/54	097A	I	Moderate Snow + Freezing Fog	Composite	-14	20°C	25	5
806	1	Duplicate	PG ADF Concentrate	46/54	097A	I	Moderate Snow + Freezing Fog	Composite	-14	20°C	25	5
807	1	Quadruplet	PG ADF Concentrate	46/54	097A	I	Moderate Snow + Freezing Fog	Composite	-14	20°C	25	5
808	1	Quadruplet	PG ADF Concentrate	46/54	097A	I	Moderate Snow + Freezing Fog	Composite	-14	20°C	25	5
809	1	Octuplet	PG ADF Concentrate	46/54	097A	I	Moderate Snow + Freezing Fog	Composite	-14	20°C	25	5
810	1	Octuplet	PG ADF Concentrate	46/54	097A	I	Moderate Snow + Freezing Fog	Composite	-14	20°C	25	5
811	1	Octuplet	PG ADF Concentrate	46/54	097A	I	Moderate Snow + Freezing Fog	Composite	-14	20°C	25	5
812	1	Octuplet	PG ADF Concentrate	46/54	097A	I	Moderate Snow + Freezing Fog	Composite	-14	20°C	25	5
813	1	Duplicate	Safewing MP II FLIGHT	100/0	023A	II	Moderate Snow + Freezing Fog	Aluminum	-14	OAT	25	5
814	1	Duplicate	Safewing MP II FLIGHT	100/0	023A	II	Moderate Snow + Freezing Fog	Aluminum	-14	OAT	25	5
815	1	Quadruplet	Safewing MP II FLIGHT	100/0	023A	II	Moderate Snow + Freezing Fog	Aluminum	-14	OAT	25	5
816	1	Quadruplet	Safewing MP II FLIGHT	100/0	023A	II	Moderate Snow + Freezing Fog	Aluminum	-14	OAT	25	5
817	1	Octuplet	Safewing MP II FLIGHT	100/0	023A	II	Moderate Snow + Freezing Fog	Aluminum	-14	OAT	25	5
818	1	Octuplet	Safewing MP II FLIGHT	100/0	023A	II	Moderate Snow + Freezing Fog	Aluminum	-14	OAT	25	5
819	1	Octuplet	Safewing MP II FLIGHT	100/0	023A	II	Moderate Snow + Freezing Fog	Aluminum	-14	OAT	25	5
820	1	Octuplet	Safewing MP II FLIGHT	100/0	023A	II	Moderate Snow + Freezing Fog	Aluminum	-14	OAT	25	5
821	1	Duplicate	AeroClear MAX	100/0	067A	III	Moderate Snow + Freezing Fog	Aluminum	-14	OAT	25	5
822	1	Duplicate	AeroClear MAX	100/0	067A	III	Moderate Snow + Freezing Fog	Aluminum	-14	OAT	25	5
823	1	Quadruplet	AeroClear MAX	100/0	067A	III	Moderate Snow + Freezing Fog	Aluminum	-14	OAT	25	5
824	1	Quadruplet	AeroClear MAX	100/0	067A	III	Moderate Snow + Freezing Fog	Aluminum	-14	OAT	25	5
825	1	Octuplet	AeroClear MAX	100/0	067A	III	Moderate Snow + Freezing Fog	Aluminum	-14	OAT	25	5
826	1	Octuplet	AeroClear MAX	100/0	067A	III	Moderate Snow + Freezing Fog	Aluminum	-14	OAT	25	5
827	1	Octuplet	AeroClear MAX	100/0	067A	III	Moderate Snow + Freezing Fog	Aluminum	-14	OAT	25	5
828	1	Octuplet	AeroClear MAX	100/0	067A	III	Moderate Snow + Freezing Fog	Aluminum	-14	OAT	25	5
829	1	Duplicate	Polar Guard Advance	100/0	090A	IV	Moderate Snow + Freezing Fog	Aluminum	-14	OAT	25	5
830	1	Duplicate	Polar Guard Advance	100/0	090A	IV	Moderate Snow + Freezing Fog	Aluminum	-14	OAT	25	5
831	1	Quadruplet	Polar Guard Advance	100/0	090A	IV	Moderate Snow + Freezing Fog	Aluminum	-14	OAT	25	5

Attachment 3: Proposed Test Plan for Testing Snow Mixed with Freezing Fog (cont'd)

Test No.	Priority	Test Type	Fluid	Dilution	APS Fluid Code	Fluid Type	Precipitation	Test Surface	Test Temp. (°C)	Fluid Temp. (°C)	Snow Rate (g/dm²/h)	Freezing Fog Rate (g/dm²/h)
832	1	Quadruplet	Polar Guard Advance	100/0	090A	IV	Moderate Snow + Freezing Fog	Aluminum	-14	OAT	25	5
833	1	Octuplet	Polar Guard Advance	100/0	090A	IV	Moderate Snow + Freezing Fog	Aluminum	-14	OAT	25	5
834	1	Octuplet	Polar Guard Advance	100/0	090A	IV	Moderate Snow + Freezing Fog	Aluminum	-14	OAT	25	5
835	1	Octuplet	Polar Guard Advance	100/0	090A	IV	Moderate Snow + Freezing Fog	Aluminum	-14	OAT	25	5
836	1	Octuplet	Polar Guard Advance	100/0	090A	IV	Moderate Snow + Freezing Fog	Aluminum	-14	OAT	25	5
837	1	Duplicate	EG106	100/0	096A	IV	Moderate Snow + Freezing Fog	Aluminum	-14	OAT	25	5
838	1	Duplicate	EG106	100/0	096A	IV	Moderate Snow + Freezing Fog	Aluminum	-14	OAT	25	5
839	1	Quadruplet	EG106	100/0	096A	IV	Moderate Snow + Freezing Fog	Aluminum	-14	OAT	25	5
840	1	Quadruplet	EG106	100/0	096A	IV	Moderate Snow + Freezing Fog	Aluminum	-14	OAT	25	5
841	1	Octuplet	EG106	100/0	096A	IV	Moderate Snow + Freezing Fog	Aluminum	-14	OAT	25	5
842	1	Octuplet	EG106	100/0	096A	IV	Moderate Snow + Freezing Fog	Aluminum	-14	OAT	25	5
843	1	Octuplet	EG106	100/0	096A	IV	Moderate Snow + Freezing Fog	Aluminum	-14	OAT	25	5
844	1	Octuplet	EG106	100/0	096A	IV	Moderate Snow + Freezing Fog	Aluminum	-14	OAT	25	5
845	2	Duplicate	PG ADF Concentrate	55/45	097A	I	Light Snow + Freezing Fog	Aluminum	-25	20°C	5	5
846	2	Duplicate	PG ADF Concentrate	55/45	097A	I	Light Snow + Freezing Fog	Aluminum	-25	20°C	5	5
847	2	Quadruplet	PG ADF Concentrate	55/45	097A	I	Light Snow + Freezing Fog	Aluminum	-25	20°C	5	5
848	2	Quadruplet	PG ADF Concentrate	55/45	097A	I	Light Snow + Freezing Fog	Aluminum	-25	20°C	5	5
849	2	Octuplet	PG ADF Concentrate	55/45	097A	I	Light Snow + Freezing Fog	Aluminum	-25	20°C	5	5
850	2	Octuplet	PG ADF Concentrate	55/45	097A	I	Light Snow + Freezing Fog	Aluminum	-25	20°C	5	5
851	2	Octuplet	PG ADF Concentrate	55/45	097A	I	Light Snow + Freezing Fog	Aluminum	-25	20°C	5	5
852	2	Octuplet	PG ADF Concentrate	55/45	097A	I	Light Snow + Freezing Fog	Aluminum	-25	20°C	5	5
853	2	Duplicate	PG ADF Concentrate	55/45	097A	I	Light Snow + Freezing Fog	Composite	-25	20°C	5	5
854	2	Duplicate	PG ADF Concentrate	55/45	097A	I	Light Snow + Freezing Fog	Composite	-25	20°C	5	5
855	2	Quadruplet	PG ADF Concentrate	55/45	097A	I	Light Snow + Freezing Fog	Composite	-25	20°C	5	5
856	2	Quadruplet	PG ADF Concentrate	55/45	097A	I	Light Snow + Freezing Fog	Composite	-25	20°C	5	5
857	2	Octuplet	PG ADF Concentrate	55/45	097A	I	Light Snow + Freezing Fog	Composite	-25	20°C	5	5
858	2	Octuplet	PG ADF Concentrate	55/45	097A	I	Light Snow + Freezing Fog	Composite	-25	20°C	5	5
859	2	Octuplet	PG ADF Concentrate	55/45	097A	I	Light Snow + Freezing Fog	Composite	-25	20°C	5	5
860	2	Octuplet	PG ADF Concentrate	55/45	097A	I	Light Snow + Freezing Fog	Composite	-25	20°C	5	5
861	2	Duplicate	Safewing MP II FLIGHT	100/0	023A	II	Light Snow + Freezing Fog	Aluminum	-25	OAT	5	5
862	2	Duplicate	Safewing MP II FLIGHT	100/0	023A	II	Light Snow + Freezing Fog	Aluminum	-25	OAT	5	5
863	2	Quadruplet	Safewing MP II FLIGHT	100/0	023A	II	Light Snow + Freezing Fog	Aluminum	-25	OAT	5	5

Attachment 3: Proposed Test Plan for Testing Snow Mixed with Freezing Fog (cont'd)

Test No.	Priority	Test Type	Fluid	Dilution	APS Fluid Code	Fluid Type	Precipitation	Test Surface	Test Temp. (°C)	Fluid Temp. (°C)	Snow Rate (g/dm²/h)	Freezing Fog Rate (g/dm²/h)
864	2	Quadruplet	Safewing MP II FLIGHT	100/0	023A	II	Light Snow + Freezing Fog	Aluminum	-25	OAT	5	5
865	2	Octuplet	Safewing MP II FLIGHT	100/0	023A	II	Light Snow + Freezing Fog	Aluminum	-25	OAT	5	5
866	2	Octuplet	Safewing MP II FLIGHT	100/0	023A	II	Light Snow + Freezing Fog	Aluminum	-25	OAT	5	5
867	2	Octuplet	Safewing MP II FLIGHT	100/0	023A	II	Light Snow + Freezing Fog	Aluminum	-25	OAT	5	5
868	2	Octuplet	Safewing MP II FLIGHT	100/0	023A	II	Light Snow + Freezing Fog	Aluminum	-25	OAT	5	5
869	2	Duplicate	AeroClear MAX	100/0	067A	III	Light Snow + Freezing Fog	Aluminum	-25	OAT	5	5
870	2	Duplicate	AeroClear MAX	100/0	067A	III	Light Snow + Freezing Fog	Aluminum	-25	OAT	5	5
871	2	Quadruplet	AeroClear MAX	100/0	067A	III	Light Snow + Freezing Fog	Aluminum	-25	OAT	5	5
872	2	Quadruplet	AeroClear MAX	100/0	067A	III	Light Snow + Freezing Fog	Aluminum	-25	OAT	5	5
873	2	Octuplet	AeroClear MAX	100/0	067A	III	Light Snow + Freezing Fog	Aluminum	-25	OAT	5	5
874	2	Octuplet	AeroClear MAX	100/0	067A	III	Light Snow + Freezing Fog	Aluminum	-25	OAT	5	5
875	2	Octuplet	AeroClear MAX	100/0	067A	III	Light Snow + Freezing Fog	Aluminum	-25	OAT	5	5
876	2	Octuplet	AeroClear MAX	100/0	067A	III	Light Snow + Freezing Fog	Aluminum	-25	OAT	5	5
877	2	Duplicate	Polar Guard Advance	100/0	090A	IV	Light Snow + Freezing Fog	Aluminum	-25	OAT	5	5
878	2	Duplicate	Polar Guard Advance	100/0	090A	IV	Light Snow + Freezing Fog	Aluminum	-25	OAT	5	5
879	2	Quadruplet	Polar Guard Advance	100/0	090A	IV	Light Snow + Freezing Fog	Aluminum	-25	OAT	5	5
880	2	Quadruplet	Polar Guard Advance	100/0	090A	IV	Light Snow + Freezing Fog	Aluminum	-25	OAT	5	5
881	2	Octuplet	Polar Guard Advance	100/0	090A	IV	Light Snow + Freezing Fog	Aluminum	-25	OAT	5	5
882	2	Octuplet	Polar Guard Advance	100/0	090A	IV	Light Snow + Freezing Fog	Aluminum	-25	OAT	5	5
883	2	Octuplet	Polar Guard Advance	100/0	090A	IV	Light Snow + Freezing Fog	Aluminum	-25	OAT	5	5
884	2	Octuplet	Polar Guard Advance	100/0	090A	IV	Light Snow + Freezing Fog	Aluminum	-25	OAT	5	5
885	2	Duplicate	EG106	100/0	096A	IV	Light Snow + Freezing Fog	Aluminum	-25	OAT	5	5
886	2	Duplicate	EG106	100/0	096A	IV	Light Snow + Freezing Fog	Aluminum	-25	OAT	5	5
887	2	Quadruplet	EG106	100/0	096A	IV	Light Snow + Freezing Fog	Aluminum	-25	OAT	5	5
888	2	Quadruplet	EG106	100/0	096A	IV	Light Snow + Freezing Fog	Aluminum	-25	OAT	5	5
889	2	Octuplet	EG106	100/0	096A	IV	Light Snow + Freezing Fog	Aluminum	-25	OAT	5	5
890	2	Octuplet	EG106	100/0	096A	IV	Light Snow + Freezing Fog	Aluminum	-25	OAT	5	5
891	2	Octuplet	EG106	100/0	096A	IV	Light Snow + Freezing Fog	Aluminum	-25	OAT	5	5
892	2	Octuplet	EG106	100/0	096A	IV	Light Snow + Freezing Fog	Aluminum	-25	OAT	5	5
893	2	Duplicate	PG ADF Concentrate	55/45	097A	I	Light Snow + Freezing Fog	Aluminum	-25	20°C	10	5
894	2	Duplicate	PG ADF Concentrate	55/45	097A	I	Light Snow + Freezing Fog	Aluminum	-25	20°C	10	5
895	2	Quadruplet	PG ADF Concentrate	55/45	097A	I	Light Snow + Freezing Fog	Aluminum	-25	20°C	10	5

Attachment 3: Proposed Test Plan for Testing Snow Mixed with Freezing Fog (cont'd)

Test No.	Priority	Test Type	Fluid	Dilution	APS Fluid Code	Fluid Type	Precipitation	Test Surface	Test Temp. (°C)	Fluid Temp. (°C)	Snow Rate (g/dm²/h)	Freezing Fog Rate (g/dm²/h)
896	2	Quadruplet	PG ADF Concentrate	55/45	097A	I	Light Snow + Freezing Fog	Aluminum	-25	20°C	10	5
897	2	Octuplet	PG ADF Concentrate	55/45	097A	I	Light Snow + Freezing Fog	Aluminum	-25	20°C	10	5
898	2	Octuplet	PG ADF Concentrate	55/45	097A	I	Light Snow + Freezing Fog	Aluminum	-25	20°C	10	5
899	2	Octuplet	PG ADF Concentrate	55/45	097A	I	Light Snow + Freezing Fog	Aluminum	-25	20°C	10	5
900	2	Octuplet	PG ADF Concentrate	55/45	097A	I	Light Snow + Freezing Fog	Aluminum	-25	20°C	10	5
901	2	Duplicate	PG ADF Concentrate	55/45	097A	I	Light Snow + Freezing Fog	Composite	-25	20°C	10	5
902	2	Duplicate	PG ADF Concentrate	55/45	097A	I	Light Snow + Freezing Fog	Composite	-25	20°C	10	5
903	2	Quadruplet	PG ADF Concentrate	55/45	097A	I	Light Snow + Freezing Fog	Composite	-25	20°C	10	5
904	2	Quadruplet	PG ADF Concentrate	55/45	097A	I	Light Snow + Freezing Fog	Composite	-25	20°C	10	5
905	2	Octuplet	PG ADF Concentrate	55/45	097A	I	Light Snow + Freezing Fog	Composite	-25	20°C	10	5
906	2	Octuplet	PG ADF Concentrate	55/45	097A	I	Light Snow + Freezing Fog	Composite	-25	20°C	10	5
907	2	Octuplet	PG ADF Concentrate	55/45	097A	I	Light Snow + Freezing Fog	Composite	-25	20°C	10	5
908	2	Octuplet	PG ADF Concentrate	55/45	097A	I	Light Snow + Freezing Fog	Composite	-25	20°C	10	5
909	2	Duplicate	Safewing MP II FLIGHT	100/0	023A	II	Light Snow + Freezing Fog	Aluminum	-25	OAT	10	5
910	2	Duplicate	Safewing MP II FLIGHT	100/0	023A	II	Light Snow + Freezing Fog	Aluminum	-25	OAT	10	5
911	2	Quadruplet	Safewing MP II FLIGHT	100/0	023A	II	Light Snow + Freezing Fog	Aluminum	-25	OAT	10	5
912	2	Quadruplet	Safewing MP II FLIGHT	100/0	023A	II	Light Snow + Freezing Fog	Aluminum	-25	OAT	10	5
913	2	Octuplet	Safewing MP II FLIGHT	100/0	023A	II	Light Snow + Freezing Fog	Aluminum	-25	OAT	10	5
914	2	Octuplet	Safewing MP II FLIGHT	100/0	023A	II	Light Snow + Freezing Fog	Aluminum	-25	OAT	10	5
915	2	Octuplet	Safewing MP II FLIGHT	100/0	023A	II	Light Snow + Freezing Fog	Aluminum	-25	OAT	10	5
916	2	Octuplet	Safewing MP II FLIGHT	100/0	023A	II	Light Snow + Freezing Fog	Aluminum	-25	OAT	10	5
917	2	Duplicate	AeroClear MAX	100/0	067A	III	Light Snow + Freezing Fog	Aluminum	-25	OAT	10	5
918	2	Duplicate	AeroClear MAX	100/0	067A	III	Light Snow + Freezing Fog	Aluminum	-25	OAT	10	5
919	2	Quadruplet	AeroClear MAX	100/0	067A	III	Light Snow + Freezing Fog	Aluminum	-25	OAT	10	5
920	2	Quadruplet	AeroClear MAX	100/0	067A	III	Light Snow + Freezing Fog	Aluminum	-25	OAT	10	5
921	2	Octuplet	AeroClear MAX	100/0	067A	III	Light Snow + Freezing Fog	Aluminum	-25	OAT	10	5
922	2	Octuplet	AeroClear MAX	100/0	067A	III	Light Snow + Freezing Fog	Aluminum	-25	OAT	10	5
923	2	Octuplet	AeroClear MAX	100/0	067A	III	Light Snow + Freezing Fog	Aluminum	-25	OAT	10	5
924	2	Octuplet	AeroClear MAX	100/0	067A	III	Light Snow + Freezing Fog	Aluminum	-25	OAT	10	5
925	2	Duplicate	Polar Guard Advance	100/0	090A	IV	Light Snow + Freezing Fog	Aluminum	-25	OAT	10	5
926	2	Duplicate	Polar Guard Advance	100/0	090A	IV	Light Snow + Freezing Fog	Aluminum	-25	OAT	10	5
927	2	Quadruplet	Polar Guard Advance	100/0	090A	IV	Light Snow + Freezing Fog	Aluminum	-25	OAT	10	5

Attachment 3: Proposed Test Plan for Testing Snow Mixed with Freezing Fog (cont'd)

Test No.	Priority	Test Type	Fluid	Dilution	APS Fluid Code	Fluid Type	Precipitation	Test Surface	Test Temp. (°C)	Fluid Temp. (°C)	Snow Rate (g/dm²/h)	Freezing Fog Rate (g/dm²/h)
928	2	Quadruplet	Polar Guard Advance	100/0	090A	IV	Light Snow + Freezing Fog	Aluminum	-25	OAT	10	5
929	2	Octuplet	Polar Guard Advance	100/0	090A	IV	Light Snow + Freezing Fog	Aluminum	-25	OAT	10	5
930	2	Octuplet	Polar Guard Advance	100/0	090A	IV	Light Snow + Freezing Fog	Aluminum	-25	OAT	10	5
931	2	Octuplet	Polar Guard Advance	100/0	090A	IV	Light Snow + Freezing Fog	Aluminum	-25	OAT	10	5
932	2	Octuplet	Polar Guard Advance	100/0	090A	IV	Light Snow + Freezing Fog	Aluminum	-25	OAT	10	5
933	2	Duplicate	EG106	100/0	096A	IV	Light Snow + Freezing Fog	Aluminum	-25	OAT	10	5
934	2	Duplicate	EG106	100/0	096A	IV	Light Snow + Freezing Fog	Aluminum	-25	OAT	10	5
935	2	Quadruplet	EG106	100/0	096A	IV	Light Snow + Freezing Fog	Aluminum	-25	OAT	10	5
936	2	Quadruplet	EG106	100/0	096A	IV	Light Snow + Freezing Fog	Aluminum	-25	OAT	10	5
937	2	Octuplet	EG106	100/0	096A	IV	Light Snow + Freezing Fog	Aluminum	-25	OAT	10	5
938	2	Octuplet	EG106	100/0	096A	IV	Light Snow + Freezing Fog	Aluminum	-25	OAT	10	5
939	2	Octuplet	EG106	100/0	096A	IV	Light Snow + Freezing Fog	Aluminum	-25	OAT	10	5
940	2	Octuplet	EG106	100/0	096A	IV	Light Snow + Freezing Fog	Aluminum	-25	OAT	10	5
941	2	Duplicate	PG ADF Concentrate	55/45	097A	I	Moderate Snow + Freezing Fog	Aluminum	-25	20°C	20	5
942	2	Duplicate	PG ADF Concentrate	55/45	097A	I	Moderate Snow + Freezing Fog	Aluminum	-25	20°C	20	5
943	2	Quadruplet	PG ADF Concentrate	55/45	097A	I	Moderate Snow + Freezing Fog	Aluminum	-25	20°C	20	5
944	2	Quadruplet	PG ADF Concentrate	55/45	097A	I	Moderate Snow + Freezing Fog	Aluminum	-25	20°C	20	5
945	2	Octuplet	PG ADF Concentrate	55/45	097A	I	Moderate Snow + Freezing Fog	Aluminum	-25	20°C	20	5
946	2	Octuplet	PG ADF Concentrate	55/45	097A	I	Moderate Snow + Freezing Fog	Aluminum	-25	20°C	20	5
947	2	Octuplet	PG ADF Concentrate	55/45	097A	I	Moderate Snow + Freezing Fog	Aluminum	-25	20°C	20	5
948	2	Octuplet	PG ADF Concentrate	55/45	097A	I	Moderate Snow + Freezing Fog	Aluminum	-25	20°C	20	5
949	2	Duplicate	PG ADF Concentrate	55/45	097A	I	Moderate Snow + Freezing Fog	Composite	-25	20°C	20	5
950	2	Duplicate	PG ADF Concentrate	55/45	097A	I	Moderate Snow + Freezing Fog	Composite	-25	20°C	20	5
951	2	Quadruplet	PG ADF Concentrate	55/45	097A	I	Moderate Snow + Freezing Fog	Composite	-25	20°C	20	5
952	2	Quadruplet	PG ADF Concentrate	55/45	097A	I	Moderate Snow + Freezing Fog	Composite	-25	20°C	20	5
953	2	Octuplet	PG ADF Concentrate	55/45	097A	I	Moderate Snow + Freezing Fog	Composite	-25	20°C	20	5
954	2	Octuplet	PG ADF Concentrate	55/45	097A	I	Moderate Snow + Freezing Fog	Composite	-25	20°C	20	5
955	2	Octuplet	PG ADF Concentrate	55/45	097A	I	Moderate Snow + Freezing Fog	Composite	-25	20°C	20	5
956	2	Octuplet	PG ADF Concentrate	55/45	097A	I	Moderate Snow + Freezing Fog	Composite	-25	20°C	20	5
957	2	Duplicate	Safewing MP II FLIGHT	100/0	023A	II	Moderate Snow + Freezing Fog	Aluminum	-25	OAT	20	5
958	2	Duplicate	Safewing MP II FLIGHT	100/0	023A	II	Moderate Snow + Freezing Fog	Aluminum	-25	OAT	20	5
959	2	Quadruplet	Safewing MP II FLIGHT	100/0	023A	II	Moderate Snow + Freezing Fog	Aluminum	-25	OAT	20	5

Attachment 3: Proposed Test Plan for Testing Snow Mixed with Freezing Fog (cont'd)

Test No.	Priority	Test Type	Fluid	Dilution	APS Fluid Code	Fluid Type	Precipitation	Test Surface	Test Temp. (°C)	Fluid Temp. (°C)	Snow Rate (g/dm²/h)	Freezing Fog Rate (g/dm²/h)
960	2	Quadruplet	Safewing MP II FLIGHT	100/0	023A	II	Moderate Snow + Freezing Fog	Aluminum	-25	OAT	20	5
961	2	Octuplet	Safewing MP II FLIGHT	100/0	023A	II	Moderate Snow + Freezing Fog	Aluminum	-25	OAT	20	5
962	2	Octuplet	Safewing MP II FLIGHT	100/0	023A	II	Moderate Snow + Freezing Fog	Aluminum	-25	OAT	20	5
963	2	Octuplet	Safewing MP II FLIGHT	100/0	023A	II	Moderate Snow + Freezing Fog	Aluminum	-25	OAT	20	5
964	2	Octuplet	Safewing MP II FLIGHT	100/0	023A	II	Moderate Snow + Freezing Fog	Aluminum	-25	OAT	20	5
965	2	Duplicate	AeroClear MAX	100/0	067A	III	Moderate Snow + Freezing Fog	Aluminum	-25	OAT	20	5
966	2	Duplicate	AeroClear MAX	100/0	067A	III	Moderate Snow + Freezing Fog	Aluminum	-25	OAT	20	5
967	2	Quadruplet	AeroClear MAX	100/0	067A	III	Moderate Snow + Freezing Fog	Aluminum	-25	OAT	20	5
968	2	Quadruplet	AeroClear MAX	100/0	067A	III	Moderate Snow + Freezing Fog	Aluminum	-25	OAT	20	5
969	2	Octuplet	AeroClear MAX	100/0	067A	III	Moderate Snow + Freezing Fog	Aluminum	-25	OAT	20	5
970	2	Octuplet	AeroClear MAX	100/0	067A	III	Moderate Snow + Freezing Fog	Aluminum	-25	OAT	20	5
971	2	Octuplet	AeroClear MAX	100/0	067A	III	Moderate Snow + Freezing Fog	Aluminum	-25	OAT	20	5
972	2	Octuplet	AeroClear MAX	100/0	067A	III	Moderate Snow + Freezing Fog	Aluminum	-25	OAT	20	5
973	2	Duplicate	Polar Guard Advance	100/0	090A	IV	Moderate Snow + Freezing Fog	Aluminum	-25	OAT	20	5
974	2	Duplicate	Polar Guard Advance	100/0	090A	IV	Moderate Snow + Freezing Fog	Aluminum	-25	OAT	20	5
975	2	Quadruplet	Polar Guard Advance	100/0	090A	IV	Moderate Snow + Freezing Fog	Aluminum	-25	OAT	20	5
976	2	Quadruplet	Polar Guard Advance	100/0	090A	IV	Moderate Snow + Freezing Fog	Aluminum	-25	OAT	20	5
977	2	Octuplet	Polar Guard Advance	100/0	090A	IV	Moderate Snow + Freezing Fog	Aluminum	-25	OAT	20	5
978	2	Octuplet	Polar Guard Advance	100/0	090A	IV	Moderate Snow + Freezing Fog	Aluminum	-25	OAT	20	5
979	2	Octuplet	Polar Guard Advance	100/0	090A	IV	Moderate Snow + Freezing Fog	Aluminum	-25	OAT	20	5
980	2	Octuplet	Polar Guard Advance	100/0	090A	IV	Moderate Snow + Freezing Fog	Aluminum	-25	OAT	20	5
981	2	Duplicate	EG106	100/0	096A	IV	Moderate Snow + Freezing Fog	Aluminum	-25	OAT	20	5
982	2	Duplicate	EG106	100/0	096A	IV	Moderate Snow + Freezing Fog	Aluminum	-25	OAT	20	5
983	2	Quadruplet	EG106	100/0	096A	IV	Moderate Snow + Freezing Fog	Aluminum	-25	OAT	20	5
984	2	Quadruplet	EG106	100/0	096A	IV	Moderate Snow + Freezing Fog	Aluminum	-25	OAT	20	5
985	2	Octuplet	EG106	100/0	096A	IV	Moderate Snow + Freezing Fog	Aluminum	-25	OAT	20	5
986	2	Octuplet	EG106	100/0	096A	IV	Moderate Snow + Freezing Fog	Aluminum	-25	OAT	20	5
987	2	Octuplet	EG106	100/0	096A	IV	Moderate Snow + Freezing Fog	Aluminum	-25	OAT	20	5
988	2	Octuplet	EG106	100/0	096A	IV	Moderate Snow + Freezing Fog	Aluminum	-25	OAT	20	5
989	2	Duplicate	PG ADF Concentrate	55/45	097A	I	Moderate Snow + Freezing Fog	Aluminum	-25	20°C	25	5
990	2	Duplicate	PG ADF Concentrate	55/45	097A	I	Moderate Snow + Freezing Fog	Aluminum	-25	20°C	25	5
991	2	Quadruplet	PG ADF Concentrate	55/45	097A	I	Moderate Snow + Freezing Fog	Aluminum	-25	20°C	25	5

Attachment 3: Proposed Test Plan for Testing Snow Mixed with Freezing Fog (cont'd)

Test No.	Priority	Test Type	Fluid	Dilution	APS Fluid Code	Fluid Type	Precipitation	Test Surface	Test Temp. (°C)	Fluid Temp. (°C)	Snow Rate (g/dm²/h)	Freezing Fog Rate (g/dm²/h)
992	2	Quadruplet	PG ADF Concentrate	55/45	097A	I	Moderate Snow + Freezing Fog	Aluminum	-25	20°C	25	5
993	2	Octuplet	PG ADF Concentrate	55/45	097A	I	Moderate Snow + Freezing Fog	Aluminum	-25	20°C	25	5
994	2	Octuplet	PG ADF Concentrate	55/45	097A	I	Moderate Snow + Freezing Fog	Aluminum	-25	20°C	25	5
995	2	Octuplet	PG ADF Concentrate	55/45	097A	I	Moderate Snow + Freezing Fog	Aluminum	-25	20°C	25	5
996	2	Octuplet	PG ADF Concentrate	55/45	097A	I	Moderate Snow + Freezing Fog	Aluminum	-25	20°C	25	5
997	2	Duplicate	PG ADF Concentrate	55/45	097A	I	Moderate Snow + Freezing Fog	Composite	-25	20°C	25	5
998	2	Duplicate	PG ADF Concentrate	55/45	097A	I	Moderate Snow + Freezing Fog	Composite	-25	20°C	25	5
999	2	Quadruplet	PG ADF Concentrate	55/45	097A	I	Moderate Snow + Freezing Fog	Composite	-25	20°C	25	5
1000	2	Quadruplet	PG ADF Concentrate	55/45	097A	I	Moderate Snow + Freezing Fog	Composite	-25	20°C	25	5
1001	2	Octuplet	PG ADF Concentrate	55/45	097A	I	Moderate Snow + Freezing Fog	Composite	-25	20°C	25	5
1002	2	Octuplet	PG ADF Concentrate	55/45	097A	I	Moderate Snow + Freezing Fog	Composite	-25	20°C	25	5
1003	2	Octuplet	PG ADF Concentrate	55/45	097A	I	Moderate Snow + Freezing Fog	Composite	-25	20°C	25	5
1004	2	Octuplet	PG ADF Concentrate	55/45	097A	I	Moderate Snow + Freezing Fog	Composite	-25	20°C	25	5
1005	2	Duplicate	Safewing MP II FLIGHT	100/0	023A	II	Moderate Snow + Freezing Fog	Aluminum	-25	OAT	25	5
1006	2	Duplicate	Safewing MP II FLIGHT	100/0	023A	II	Moderate Snow + Freezing Fog	Aluminum	-25	OAT	25	5
1007	2	Quadruplet	Safewing MP II FLIGHT	100/0	023A	II	Moderate Snow + Freezing Fog	Aluminum	-25	OAT	25	5
1008	2	Quadruplet	Safewing MP II FLIGHT	100/0	023A	II	Moderate Snow + Freezing Fog	Aluminum	-25	OAT	25	5
1009	2	Octuplet	Safewing MP II FLIGHT	100/0	023A	II	Moderate Snow + Freezing Fog	Aluminum	-25	OAT	25	5
1010	2	Octuplet	Safewing MP II FLIGHT	100/0	023A	II	Moderate Snow + Freezing Fog	Aluminum	-25	OAT	25	5
1011	2	Octuplet	Safewing MP II FLIGHT	100/0	023A	II	Moderate Snow + Freezing Fog	Aluminum	-25	OAT	25	5
1012	2	Octuplet	Safewing MP II FLIGHT	100/0	023A	II	Moderate Snow + Freezing Fog	Aluminum	-25	OAT	25	5
1013	2	Duplicate	AeroClear MAX	100/0	067A	III	Moderate Snow + Freezing Fog	Aluminum	-25	OAT	25	5
1014	2	Duplicate	AeroClear MAX	100/0	067A	III	Moderate Snow + Freezing Fog	Aluminum	-25	OAT	25	5
1015	2	Quadruplet	AeroClear MAX	100/0	067A	III	Moderate Snow + Freezing Fog	Aluminum	-25	OAT	25	5
1016	2	Quadruplet	AeroClear MAX	100/0	067A	III	Moderate Snow + Freezing Fog	Aluminum	-25	OAT	25	5
1017	2	Octuplet	AeroClear MAX	100/0	067A	III	Moderate Snow + Freezing Fog	Aluminum	-25	OAT	25	5
1018	2	Octuplet	AeroClear MAX	100/0	067A	III	Moderate Snow + Freezing Fog	Aluminum	-25	OAT	25	5
1019	2	Octuplet	AeroClear MAX	100/0	067A	III	Moderate Snow + Freezing Fog	Aluminum	-25	OAT	25	5
1020	2	Octuplet	AeroClear MAX	100/0	067A	III	Moderate Snow + Freezing Fog	Aluminum	-25	OAT	25	5
1021	2	Duplicate	Polar Guard Advance	100/0	090A	IV	Moderate Snow + Freezing Fog	Aluminum	-25	OAT	25	5
1022	2	Duplicate	Polar Guard Advance	100/0	090A	IV	Moderate Snow + Freezing Fog	Aluminum	-25	OAT	25	5
1023	2	Quadruplet	Polar Guard Advance	100/0	090A	IV	Moderate Snow + Freezing Fog	Aluminum	-25	OAT	25	5

Attachment 3: Proposed Test Plan for Testing Snow Mixed with Freezing Fog (cont'd)

Test No.	Priority	Test Type	Fluid	Dilution	APS Fluid Code	Fluid Type	Precipitation	Test Surface	Test Temp. (°C)	Fluid Temp. (°C)	Snow Rate (g/dm²/h)	Freezing Fog Rate (g/dm²/h)
1024	2	Quadruplet	Polar Guard Advance	100/0	090A	IV	Moderate Snow + Freezing Fog	Aluminum	-25	OAT	25	5
1025	2	Octuplet	Polar Guard Advance	100/0	090A	IV	Moderate Snow + Freezing Fog	Aluminum	-25	OAT	25	5
1026	2	Octuplet	Polar Guard Advance	100/0	090A	IV	Moderate Snow + Freezing Fog	Aluminum	-25	OAT	25	5
1027	2	Octuplet	Polar Guard Advance	100/0	090A	IV	Moderate Snow + Freezing Fog	Aluminum	-25	OAT	25	5
1028	2	Octuplet	Polar Guard Advance	100/0	090A	IV	Moderate Snow + Freezing Fog	Aluminum	-25	OAT	25	5
1029	2	Duplicate	EG106	100/0	096A	IV	Moderate Snow + Freezing Fog	Aluminum	-25	OAT	25	5
1030	2	Duplicate	EG106	100/0	096A	IV	Moderate Snow + Freezing Fog	Aluminum	-25	OAT	25	5
1031	2	Quadruplet	EG106	100/0	096A	IV	Moderate Snow + Freezing Fog	Aluminum	-25	OAT	25	5
1032	2	Quadruplet	EG106	100/0	096A	IV	Moderate Snow + Freezing Fog	Aluminum	-25	OAT	25	5
1033	2	Octuplet	EG106	100/0	096A	IV	Moderate Snow + Freezing Fog	Aluminum	-25	OAT	25	5
1034	2	Octuplet	EG106	100/0	096A	IV	Moderate Snow + Freezing Fog	Aluminum	-25	OAT	25	5
1035	2	Octuplet	EG106	100/0	096A	IV	Moderate Snow + Freezing Fog	Aluminum	-25	OAT	25	5
1036	2	Octuplet	EG106	100/0	096A	IV	Moderate Snow + Freezing Fog	Aluminum	-25	OAT	25	5

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APPENDIX C

PROCEDURE:
ENDURANCE TIME TESTING IN SIMULATED FREEZING PRECIPITATION WITH SAE TYPE I, II, III, AND IV DE/ANTI-ICING FLUIDS

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PROCEDURE:

ENDURANCE TIME TESTING IN SIMULATED FREEZING PRECIPITATION WITH SAE TYPE I, II, III, AND IV DE/ANTI-ICING FLUIDS

Prepared for

Transportation Development Centre
Transport Canada

Prepared by: Benjamin Bernier

Reviewed by: John D'Avirro

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Final Version 1.0

PROCEDURE: ENDURANCE TIME TESTING IN SIMULATED FREEZING PRECIPITATION WITH SAE TYPE I, II, III, AND IV DE/ANTI-ICING FLUIDS

1. BACKGROUND

The Society of Automotive Engineers (SAE) has published standards detailing acceptable practices for endurance time testing in simulated freezing precipitation conditions. The Aerospace Recommended Practice (ARP) documents ARP5945 and ARP5485 outline these practices for Type I and Type II/III/IV anti-icing fluids, respectively. These documents set the requirements for fluid samples, testing materials, test conditions, and test practices for anti-icing fluid endurance time testing. These standards are continually reviewed and updated at the discretion of the SAE Holdover Time committee.

APS has been conducting outdoor simulated freezing precipitation endurance time testing with the goal of measuring the effectiveness of new holdover time fluids since the early 1990's. All testing is conducted in accordance with the established SAE standards, ARP5945 and ARP5485.

This procedure serves as an update to the previous APS procedure, *Test Requirements for Simulated Freezing Precipitation Flat Plate Testing*, which was issued in January 2004. This new document serves to incorporate refinements to the procedure that have been made in the intervening years, as well as to provide additional information relating to event planning and APS specific processes.

2. OBJECTIVE

This procedure describes the testing procedures used to evaluate the endurance time performance of Type I, II, III and IV fluids in simulated freezing precipitation conditions.

This procedure also describes the testing procedure used to measure fluid thickness profiles of Type I, II, III and IV fluids.

A related procedure is produced annually containing year-specific test plans, equipment needs, as well as details on other projects being undertaken during the annual simulated freezing precipitation holdover time test session.

3. PRE-TESTING ACTIVITIES

This section describes activities that need to be performed prior to commencing a simulated freezing precipitation testing session.

3.1. Event Coordination and Scheduling

Simulated freezing precipitation testing is a highly coordinated activity requiring the use of advanced testing facilities, numerous personnel (from both APS and the NRC), and significant resources. To that end, a significant effort must be put into planning these activities in order to keep testing running as smoothly, with as few costly disruptions as possible.

A typical test session will require that all fluids being qualified are tested in every simulated freezing precipitation condition found within a typical fluid holdover time table. This results in testing being done in discrete blocks (referred to as “conditions”) which are defined by the following:

- Precipitation Type;
- Test Temperature; and
- Target Precipitation Rate.

These parameters of each condition are designed to replicate the boundary conditions governing each freezing precipitation holdover time table cell.

Given that each fluid being tested must be tested in all boundary conditions, each simulated freezing precipitation test session will consist of a known amount of conditions, each of whose length can be estimated with the following information:

- Number of tests to be run (determined by the number of fluids to be tested); and
- Expected endurance time of each test (estimated based on fluid performance in natural snow).

Additionally, each fluid being qualified must also undergo fluid film thickness testing. This is generally performed concurrently with the standard endurance time testing, but must also be accounted for when scheduling a test session. As fluid film thickness testing is conducted at a chamber temperature of -3°C, the testing should be scheduled to be done during the -3°C condition blocks.

It is the responsibility of the event coordinator to arrange the schedule of conditions in such a way as to ensure that each testing day will conclude at an appropriate time, and that time between conditions is minimized. To this end, like precipitation types/temperatures should be grouped as much as possible to avoid unnecessary temperature and spray equipment changes.

3.2. Data Requirements and test Planning

Unlike natural snow testing, where data is gathered at a range of rates and temperatures, simulated freezing precipitation testing is conducted at a specific set of rates and temperatures representing the boundary conditions for each precipitation type. Table 3.1 lists all of the test conditions that comprise a standard simulated freezing precipitation holdover time test session.

Table 3.1: Standard Holdover Time Freezing Precipitation Test Conditions

Condition Abbreviation	Precipitation Type	OAT (°C)	Test Rate (g/dm²/h)	Notes
ZF, -3, 2	Freezing Fog	-3	2	
ZF, -3, 5	Freezing Fog	-3	5	
ZF, -10, 2	Freezing Fog	-10	2	Type III only
ZF, -10, 5	Freezing Fog	-10	5	Type III only
ZF, -14, 2	Freezing Fog	-14	2	
ZF, -14, 5	Freezing Fog	-14	5	
ZF, -25, 2	Freezing Fog	-25	2	
ZF, -25, 5	Freezing Fog	-25	5	
ZF, -35, 2	Freezing Fog	-35	2	LOUT ≤ -29.5°C
ZF, -35, 5	Freezing Fog	-35	5	LOUT ≤ -29.5°C
ZD, -3, 5	Freezing Drizzle	-3	5	
ZD, -3, 13	Freezing Drizzle	-3	13	
ZD, -6, 5	Freezing Drizzle	-6	5	Type I only
ZD, -6, 13	Freezing Drizzle	-6	13	Type I only
ZD, -10, 5	Freezing Drizzle	-10	5	
ZD, -10, 13	Freezing Drizzle	-10	13	
ZR, -3, 13	Freezing Rain	-3	13	
ZR, -3, 25	Freezing Rain	-3	25	
ZR, -6, 13	Freezing Rain	-6	13	Type I only
ZR, -6, 25	Freezing Rain	-6	25	Type I only
ZR, -10, 13	Freezing Rain	-10	13	
ZR, -10, 25	Freezing Rain	-10	25	
CS, 1, 5	Rain on Cold Soaked Wing	-1	5	
CS, 1, 75	Rain on Cold Soaked Wing	-1	75	

As the test conditions are standardized and finite in number, the amount of tests required for a given fluid in a typical HOT test session is always known. For thickened fluids, this number is determined by how many dilutions are to be tested, as well as the fluid LOUT. For Type I fluids, data must be obtained using both aluminum and composite test surfaces for all conditions. Table 3.2 lists the data requirements in simulated freezing precipitation for all fluid types.

Table 3.2: Freezing Precipitation Data Requirements

Fluid Type, Dilution(s)	Fluid LOUT	Number of Tests Required
Type I	Any	56
Type II/IV, Neat Only	Above -29.5°C	32
	-29.5°C or Below	36
Type II/IV, All Dilutions	Above -29.5°C	72
	-29.5°C or Below	76
Type III, Neat Only	Above -29.5°C	32
	-29.5°C or Below	36
Type III, All Dilutions	Above -29.5°C	72
	-29.5°C or Below	76

Note that the totals in the above table do not include any tests which must be repeated (see Subsection 5.4.3 for details relating to repeated tests).

Refer to the above tables when planning an upcoming freezing precipitation test event; tests must be planned for each appropriate condition, and the number of tests for a given fluid should be equivalent to the appropriate number from the table above.

As a reminder, test plans for a given simulated freezing precipitation testing session are included in a related procedure that is prepared annually prior to that year's testing session.

3.3. Equipment Preparation

As all simulated freezing precipitation testing takes place at the NRC-CEF in Ottawa, there are several equipment preparation activities that must be completed prior to arrival at the NRC facility. These activities are as follows:

1) Mark all test surfaces with gridlines and with plate numbers on the back and front (note that markings should be at the bottom of the test surfaces);
2) Ensure all test plates are equipped with operational thermistors or smart button, and ensure that all temperature loggers have been properly configured. Loggers must be able to log a full week's worth of data as data will only be exported at the end of each testing week;
3) Locate the rate pans: check the quantity, confirm that all pans properly labelled and fully intact (no holes/cracks), and verify that spare pans are available;
4) Prepare labels for pour containers, as needed;
5) Confirm that the primary and backup rate station laptops are working normally, confirm that the rate station software runs on both laptops;
6) Confirm that the primary and backup rate station weigh scales are working normally, confirm that both weigh scales are communicating properly with both the primary and backup rate station laptops; and
7) Ensure that sufficient copies of all data forms, procedures and condition sheets have been printed in advance.

3.4. Fluid Preparation Management

This section describes the steps necessary to ensure that the fluids to be tested are properly prepared for testing.

3.4.1. Type I Fluid Preparation

Type I fluids will generally be sent to APS by the manufacturer in concentrate form. Prior to commencing a test session, appropriately buffered mixtures of the fluid must be prepared for each test temperature that is planned for the session. As per ARP5945A, Type I fluids must be tested at dilutions where the freezing point of the solution is 10°C colder than the OAT at which testing is taking place.

To prepare the buffered solution, you must first identify the temperatures at which the testing will take place. Separate solutions must be prepared for each discrete testing temperature, and each prepared solution must be stored at the correct temperature. For example, if the daily schedule calls for tests at both -3°C and -10°C, two separate batches of Type I fluid must be prepared (with freezing points of -13°C and -20°C respectively). Each batch must be stored at ambient room temperature (20°C).

The Type I concentrate must be diluted with hard water, which is prepared by dissolving 400mg of calcium acetate dehydrate and 280 mg of magnesium sulfate heptahydrate into 1L of water (the quantities can be scaled up proportionally if preparing a larger batch). Consult the dilution chart associated with the Type I fluid being tested in order to determine the appropriate glycol/hard water ratio necessary to achieve the desired freeze point. Dilution charts are generally available on the fluid manufacturer's website or directly from the manufacturer.

Confirm that the glycol concentration in your prepared solution is appropriate by measuring the Brix (generally Type I dilution charts will indicate the target Brix for the desired fluid freeze point). Ensure that the container in which the solution is mixed is clearly marked with the freeze point and Brix of the fluid. Pour container labels listing the fluid name, Brix and freeze point should also be created and affixed to all pour containers to be used during the test session.

Note that although ARP5945A stipulates that Type I fluid samples be sheared in a laboratory blender prior to testing, previous work has indicated that the effects of this shearing process on resulting Type I fluid endurance times are negligible. The Type I fluid shearing process is generally not performed with fluid samples as part of the typical simulated freezing precipitation testing process.

3.4.2. Type II/III/IV Fluid Management

In order to ensure that a testing session runs smoothly with minimal disruptions, it is critical that a sufficient number of filled 1L pour containers for each fluid to be tested are prepared and tempered prior to the start of a given test condition. The required amount of each fluid for each condition will be known in advance; it is good practice to have additional fluid ready for testing in the event of unexpected circumstances.

Used pour containers should be periodically refilled when time permits to prevent delays in the fluid application process. At a minimum, empty pour containers should be refilled at the conclusion of each testing day. All pour containers must be affixed with labels listing the fluid name, batch number and dilution and special care must be taken when refilling to ensure that the proper fluid, batch and dilution are used. At the testing manager's discretion, the fluid names on the pour container labels may need to be coded to preserve fluid anonymity in the presence of visitors.

All fluids to be used in simulated freezing precipitation endurance time testing must be properly stored in order to ensure that they are at the correct temperature when a test session begins. Given that simulated freezing precipitation testing takes place at several discrete testing temperatures, a series of programmable chest freezers set

to the various testing temperatures should be available at the NRC such that a sufficient quantity of fluid can be kept at each temperature being tested.

Fluid can also be stored within the test chamber itself, provided that the temperature of the chamber is the desired storage temperature for the fluid in question.

As stated in ARP5485B, the temperature of Type II, III (unheated) or IV fluid being applied to a test surface in a simulated freezing precipitation endurance time test must be within 3°C (ideally 1°C) of the OAT. Valuable testing time can be lost waiting for fluids to temper if the proper storage procedures have not been followed.

4. TEST SITE

All testing in simulated freezing precipitation is conducted indoors at the National Research Council Canada (NRC) Climatic Engineering Facility (CEF) located in Ottawa Canada, where precipitation is artificially produced using a specialized spray assembly capable of producing droplets of precisely calibrated size. This spray assembly (and the nozzles it contains) were developed by the NRC in conjunction with APS over the course of several years of research.

Photo 4.1 provides an outdoor view of the facility (U-88) giving a general indication of its size (30 m by 5.4 m, height 8 m). The facility was originally designed for the testing of locomotives; Photo 4.2 provides an interior view of the CEF set up for endurance time testing. The lowest temperature achievable in the CEF is -46°C.

Photo 4.1: Outdoor View of NRC Climatic Engineering Facility

Photo 4.2: Inside View of NRC Climatic Engineering Facility

5. TESTING PROCEDURES

This section describes the procedures to be followed during a simulated freezing precipitation test event.

The procedures conform to the requirements for simulated freezing precipitation testing outlined in Section 11 of ARP5485B – *Endurance Time Tests for Aircraft Deicing/Anti-icing Fluids, SAE Type II, III, and IV*.

The procedures also conform to the requirements for simulated freezing precipitation testing outlined in Section 11 of ARP5945A – *Endurance Time Tests for Aircraft Deicing/Anti-icing Fluids, SAE Type I*.

5.1. Set-Up

The set-up steps to be performed once upon initial arrival at the CEF for a freezing precipitation endurance time testing session are listed below:

1) Unload all equipment from the truck upon arriving at the CEF. General equipment boxes should be stored in the women's washroom off of the client area. Office equipment is to be kept in the client area.
2) Set up the fluid storage freezers within the hallway off of the client area. Ensure that there is a freezer set to each of the target test temperatures at which testing will take place during the test session.
3) Set up the rate station within the client area: ensure that the scale being used is properly leveled and test that the scale and chosen rate station computer are functioning normally together.
4) Store the jugs cold soaked box fluid (brought from the test site) inside the cold NRC freezer and confirm that the freezer is set to < -30°C.
5) Set up two full six-position test stands within the spray area inside the testing chamber. The initial position of the test stands is dependent upon the first condition being tested; refer to the NRC Continuous Rate form to determine the appropriate starting position for the test stands. Ensure the stands are levelled such that the test surfaces lie at a 10° angle (within 9.8° and 10.2° is acceptable, check each test surface). The angle of the test stand can be adjusted as needed by placing poker chips under the stand legs. Whenever the configuration is adjusted by adding or removing chips ensure that the stand is reasonably stable and that all test surfaces are at the proper angle. Ensure the fluid collection pans are placed beneath the test stands to collect fluid runoff, however equip the collection pans with white covers to prevent their filling with sprayed precipitation.

6) Equip the two six-position test stands with aluminum test plates. Half plates may be used for one test in each duplicate pair of tests in order to increase the number of available test positions. Note that Type I fluids need to be tested on both composite and aluminum test surfaces, test surfaces can be adjusted on the test stands as needed. Note also that a special test surface is used for rain on cold-soaked wing condition testing with all fluid types. See Subsection 5.6 for additional details. All test plates used must be equipped with Smart Buttons that are actively logging temperature data. Ensure that Position #1 on the top stand is left open for the NRC Automated Rate bucket. Figure 5.1 depicts the proper plate set-up for the two test stands.

7) Sync all digital clocks and install them in the large end of the test chamber (near spray area), and in the small end of the test chamber.

8) Confirm that the NRC personnel have properly set-up the closed-circuit camera system. It is critical that the camera system provides a good view of the testing area; the rate station manager must be able to have a clear view of the test stands while seated at the rate station. Ensure that the digital clocks are visible on the camera screens.

9) Post copies of the condition testing schedules and rate tolerance guidelines inside the client area.

10) Fill out the General Session Conformance Checklist (Attachment 1)

11) Prior to departing the facility on setup day, confirm that all personnel (NRC/APS) are aware of the starting time and initial test condition for the first testing day.

Figure 5.1: Test Stand Set-Up

5.2. Testing Process for a Typical Condition

A simulated freezing precipitation endurance time testing session is comprised of discrete blocks of tests known as conditions. Different conditions will vary in terms of precipitation type, precipitation rate and test chamber temperature.

The general flow of work for each condition is very similar; the steps in the testing process are listed below:

1) Confirm the condition being tested with NRC personnel. NRC personnel will install the proper spraying equipment/needles and set the flow rate specific to the condition precipitation type and will set the testing chamber temperature to the appropriate target test temperature.

2) While NRC personnel are configuring the chamber and spray equipment, APS personnel must confirm that the test stands are in the proper starting position relative to the condition being tested (refer to the NRC Continuous Rate Form for proper stand position coordinates). Ensure that the test stands are equipped with the appropriate test surfaces, and confirm that all fluids to be tested in the upcoming condition are at the appropriate temperature.

3) Once the chamber has reached the appropriate temperature, NRC personnel will activate the spraying equipment and begin precipitation.

4) Once precipitation has begun, pre-test rate collection and calibration takes place. This process continues until stable, in-tolerance rates have been achieved on a sufficient number of test stand positions to allow testing. In order for a position to be used for testing, two consecutive in-tolerance rates must have been recorded on that position.

5) All required endurance time tests are conducted and the results are validated. Note that for a given condition, the number of tests to be conducted will be known beforehand and all tests to be run will be listed on a condition-specific test plan known as a “Condition Sheet”. Two data points must be collected with each dilution of each fluid being tested in a given condition. Note that if the endurance time results obtained failed to satisfy preliminary data validation checks, supplemental test runs may be required.

6) As endurance time tests are completed, post-testing rate collection cycles are performed. Two rate collection cycles are required for a given position after an endurance time test is completed.

7) After the final post-test rate collection cycle is complete, the condition is considered complete. Rate and endurance time data processing takes place, and APS/NRC personnel can begin their set-up steps for the following condition.

5.3. Rate Collection

The rate collection process for simulated freezing precipitation differs significantly from the process employed during natural snow. Unlike natural snow rate collection, where one rate pan in one position is used to collect rates for the entire test stand, rate collection in simulated freezing precipitation is performed on each position of the test stand that is used for testing, resulting in unique rates being obtained for each position.

Additionally, while natural snow rate collection is a continuous process (occurring before, during and after a test), simulated freezing precipitation rate collection is performed only immediately prior and immediately following an endurance time test. The test rate for a given freezing precipitation endurance time test is determined by taking the average of four recorded rates; two rates taken immediately prior to the test, and two rates taken immediately following the test. All rates associated with a test must be collected from the same position on which the test is conducted. Similar to natural snow rate collection, the target time period for a recorded rate is ten minutes.

Test rates for simulated freezing precipitation endurance time tests must fall within a set of tolerances stipulated within ARP5945A and ARP5485B (for Type I and Type II/III/IV fluids, respectively). These tolerances dictate allowable ranges for the average rate of a test, as well as the allowable standard deviation of the individual rate measurements comprising a test rate. These tolerances are condition specific; they vary depending on precipitation type and target test rate. It is the responsibility of the rate station manager to ensure that test rates are falling within these tolerances; out-of-tolerance rates can result in the invalidation of an endurance time test. Table 5.1 lists the average test rate tolerances for the various simulated freezing precipitation conditions.

Table 5.1: Simulated Freezing Precipitation Average Test Rate Tolerances

Precipitation Type	Target Test Rate ($g/dm^2/h$)	Tolerance for Average Test Rate ($g/dm^2/h$)
Freezing Fog	2	±0.3
	5	±0.4
Freezing Drizzle	5	±0.4
	13	±0.5
Freezing Rain	13	±0.5
	25	±1.0
Rain on Cold Soaked Wing	5	±0.4
	75	±3.0

5.3.1. Procedure for Rate Collection

The rate collection process is generally performed by the rate station manager with two Ottawa personnel assisting. The steps for rate collection in simulated freezing precipitation are summarized below:

1) Open the rate station software (RateStation.Winforms). Complete initial configuration of the rate station software by selecting your test condition and specifying the temperature. If any positions on the test stand are not being used for testing in a given condition, retire them immediately in the software by clicking the "Retire" button under the unused positions.

2) Open a copy of the Excel sheet used to record the rates (RateStationTemplate). Rename the Excel sheet with a name that describes the condition being (ex. "ZD -10 5 - 2018-19" for low rate freezing drizzle at -10°C) and close the file.

3) Confirm that the test stands are in the correct starting position for the condition being tested (refer to the NRC Continuous Rate Form which lists the stand starting positions for each condition)

4) Ask NRC personnel to configure the automated rate bucket and the corresponding automated rate software. Note that the automated rate bucket is generally installed on Position 1 and that the automated rate software will run on a separate NRC-owned computer.

5) Ensure that the rate station scale is level, and pre-weigh dry "Inside" rate pans for all unretired positions. To record the pre-weight of the pans in the rate station software, click "Start Rate" under the appropriate position and input the weight from the scale in the "Weight" dialog box. Do not click "Start" after recording the pre-weight – this will signal to the software that the rate collection period has begun for that position.

6) Note that each numbered rate pan set corresponds to a specific numbered position on the test stand (see Figure 5.1) and consists of an "Inside" and an "Outside" plastic pan; whenever a pan is being weighed, only the "Inside" pans are to be placed on the scale. After weighing an "Inside" pan, place it back inside its corresponding "Outside" pan. Once all pans are pre-weighed, arrange them in numerical order on the shelves adjacent to the rate station. Figure 5.2 depicts the rate station software window after all pre-weights have been recorded (but before any rate cycles have begun).

7) Once the NRC personnel have started the precipitation for the condition, begin collecting initial rates for all available positions. In a typical two test stand set up, positions 2 through 12 should all be initially available. Bring the empty pans (Inside + Outside together) into the test chamber, and carefully place them on their respective positions one at a time, taking care

to avoid covering other positions with the rate pan as it is placed on the stand. The rate station manager is to monitor this process closely on the NRC cameras; as each pan is placed on the stand, the rate station manager must click the "Start" button for the position in question to indicate the start of the rate collection period.

8) As the ten-minute mark of the initial rate cycle approaches, begin collecting the rates pans from the test stand and returning them to the rate station, again in numerical order. Ensure that no precipitation is lost from inside each pan as they are transported – any lost precipitation will cause inaccuracies in the measured rate for that collection period. The rate station manager must once again monitor the process closely, and click the appropriate "Stop Rate" button at the moment that each pan is collected, signalling the end of the rate collection period. A dialog box will appear prompting the user for the final weight of the collection pan.

9) Weigh the "Inside" pans, record the weight in the dialog box and click "Save Rate". Repeat this process for each of the pans collected.

10) As the final weights are entered, the program will automatically calculate the measured rate of precipitation over the collection period for each position. The program will show the calculated rate on the screen, highlighted either green (for an in-tolerance rate) or red (for an out-of-tolerance rate). Figure 5.3 depicts the rate station software window after one cycle of rates have been collected for each available position in a standard two stand set-up, with both in and out of tolerance rates being shown.

11) After the initial rate cycle is complete (and prior to starting the second rate cycle), review the measured rates shown on-screen. If most or all positions are out-of-tolerance and a consistent trend is noted in the rates (i.e. all too high or all too low), consider asking the NRC personnel to adjust the back pressure (lower if rates are too high, higher if rates are too low).

12) If changing the back pressure does not bring the rates back in tolerance, or if there is no discernable trend in the rates across the positions, consider adjusting the position of the test stands. If making any adjustments, allow time for the adjustment to be made and come into effect before bringing pans back out to start a new rate cycle.

13) Begin a second rate cycle with all pans, repeating the same process as was completed for the first cycle.

14) After the second cycle is complete, the rate station manager can begin allocating positions to the testing team provided that both measured rates on the position in question are within tolerance. Tests can only be run on positions that have had two consecutive valid rates collected. Making further changes to the back-pressure settings or stand position after testing

has begun is discouraged – it is generally advisable to adjust early in the process with the goal of bringing as many positions in tolerance as possible.

15) Once a given position has been allocated for use to the testing team, click "Start Test" in the rate station software window. The display for this position will change colour, and will indicate that a test is running. At this point, rate pans will no longer need to be placed on this position until the testing team has completed their test(s). Figure 5.4 depicts the rate station software window with several active tests running (test numbers have been added).

16) After the testing team pours a test on an allocated position, input the test number in the "Test #" section in the software.

17) If two tests are poured simultaneously on a position equipped with half-plates, input both test numbers separated by a slash (ex. 6/7, with test 6 being poured on the left-hand half plate and test 7 being poured on the right hand half-plate).

18) If two tests are poured consecutively on a position (known as a "test-test"), input both test numbers separated by a plus sign (ex. 6+7, with test 6 being poured first and test 7 being poured on the same position after test 6 is complete.

19) Continue rate collection cycles on all positions that are not currently allocated for testing. Positions can be allocated to the testing team whenever two consecutive in-tolerance rates are obtained. Ensure that at all times rate cycles are continuously run on a minimum of one position – unexpected changes in the measured rates on this position will highlight changes in precipitation that may be difficult to detect otherwise.

20) When the testing team has completed their tests on a given position, they will communicate to the rate station manager that the position in question is now ready for post-test rates. Click "End Test" in the rate station software window for the position in question, and resume rate collection cycles on this position. A minimum of two post-test rate collection cycles must be completed in order to generate the final test rate for all tests run on that position. If the two post test rate cycles generate in-tolerance rates, the position can immediately be allocated back to the testing team (if more tests are to be run).

21) Once all tests and post-test rate cycles have been completed for a given condition, the rate data must be exported from the rate station software. To do so, click "Fill Excel Sheet" in the rate station software and locate the previously created Excel file.

22) Once the Excel sheet is populated, open the "Output" tab in the Excel file. Click "Update All" – the sheet will now process all of the imported rate

data. Once complete, the rates for all tests run in the condition should be shown in this tab.

23) Double check that test numbers for all tests run in the condition appear in Column D (refer to the condition sheet to confirm nothing was missed), and click "Status Calculator". The sheet will now verify that the rates for each test are conforming to the tolerances stipulated. Results of the checks are shown in columns P, Q and R. If any of the tests fail any of the tolerance checks, advise the testing manager – they will make the decision whether to re-run the affected tests.

24) Once confirmed that all tests are present in the Excel sheet with in-tolerance rates, print out a copy of the details in the Output tab (columns D through S) and provide the printout to the testing assistant for filing.

25) Finally, at the conclusion of each condition, assess the overall difficulty of the rate process for that condition on a scale from 1-5 and note this difficulty on the NRC Continuous Rate Form.

Figure 5.2: Rate Station Software Window after Pre-Weighing of Pans

Figure 5.3: Rate Station Software Window after One Rate Cycle

Figure 5.4: Rate Station Software Window with Active Tests Running

5.3.2. Challenges and Additional Information Concerning Rate Collection

Note that managing the rate station is a challenging role which requires a large amount of focus. The rate station manager should work closely with both the testing manager and NRC personnel in order to obtain valid, in-tolerance rates on as many positions as possible. Obtaining in-tolerance rates is not always straight-forward, and the challenge varies from condition to condition. Frequently, the rate station manager will need to make a decision between allocating fewer in-tolerance plates to the testing team (thus reducing the amount of tests that can be run concurrently) or attempting to tweak the water flow back pressure settings / stand positioning further (which delays the start of testing, with the goal of freeing up more usable positions).

The rate station manager should refer to the "Continuous Rate Form" in order to obtain an understanding of the relative difficulties of rate collection in the different conditions as well as the approximate values to be expected as continuous outputs from the automated rate bucket. This knowledge is helpful when attempting to make the "tweak or test" decisions alluded to in the previous paragraph. Finally, an internal companion document has been developed detailing common issues encountered during rate collection and troubleshooting suggestions. This document is available of the APS server.

5.4. Fluid Endurance Time Tests

The steps for conducting simulated freezing precipitation fluid endurance time tests are summarized below.

5.4.1. Procedure for Testing Unheated Fluids (Type II, III-Unheated, and IV)

1) Prepare the data form / data form app by recording the fluids to be poured in their respective positions.
2) Measure the initial fluid temperature of all fluids that are to be poured during the test session. Confirm that all fluids are within 3°C (ideally 1°C) of the current target test temperature. If fluids are not at the correct temperature, warm them in the client area or cool them in a chest freezer as needed.
3) Coordinate with the rate station manager to determine which positions on the test stand have rates suitable for testing.
4) Once test stand positions have been allocated to the testing team by the rate station manager, clear the test surfaces to be used of existing contamination using a scraper. To ensure that each position is properly cleaned, apply a small quantity of the fluid being tested to the test surface and use a squeegee to spread it across the full test surface.

5) Confirm that the data form manager is ready to begin the fluid application process. At each position, remove the plate cover and pour 1L of the selected fluid onto the test surface from the top of the plate, ensuring that the entire surface of the plate is coated with an even fluid layer. During the pouring process, use the removed plate cover to shield the test surface from the falling precipitation. Record the time of fluid application on the chosen data form.

6) After fluid application is complete, each plate must be inspected periodically in order to assess the condition of the fluid layer. A section of the plate is considered failed when it is covered with frozen contamination.

7) If more than one-third of a given plate is determined to be "failed" (or if fluid failure is noted at any five of the crosshair marks on the plate), the plate as a whole is considered to be failed. Announce the fluid failure and ensure the failure time is recorded by the data form manager. Place a "poker chip" on the plate once failure has been declared to indicate that the plate is no longer running an active test.

8) Alternately, if a test reaches the maximum run time (representing the maximum allowable holdover time for the freezing precipitation condition being tested), the test can be stopped immediately. For freezing fog, the maximum run time is four hours. For all other simulated freezing precipitation conditions, that maximum run time is two hours. The data form manager must note that the test did not fail (typically by noting "Did Not Fail (DNF)" on the data form).

9) If there are no other tests currently running or immediately to be run on the position, reinstall the plate cover and signal the rate station manager to begin post-test rate collection cycles. Note that a given position can be used for no more than two consecutive tests; post-test rate collection cycles must be performed after the second consecutive test.

10) Ensure fluid for the next condition is available and tempered to the correct temperature.

5.4.2. Procedure for Testing Heated Fluids (Type I and III-Heated)

1) Prepare the data form / data form app by recording the fluids to be poured in their respective positions.

2) Measure the initial fluid temperature of all fluids that are to be poured during the test session. Confirm that all fluids are within 5°C (ideally 1°C) of 20°C. If fluids are not at the correct temperature, warm them in the client area or cool them in a chest freezer as needed.

3) Coordinate with the rate station manager to determine which positions on the test stand have rates suitable for testing.

4) Once test stand positions have been allocated to the testing team by the rate station manager, clear the test surfaces to be used of existing contamination using a scraper. To ensure that each position is properly cleaned, apply a small quantity of the fluid being tested to the test surface and use a squeegee to spread it across the full test surface.

5) Confirm that the data form manager is ready to begin the fluid application process. At each position, remove the plate cover and pour 1L of the selected fluid onto the test surface from the top of the plate, ensuring that the entire surface of the plate is coated with an even fluid layer. During the pouring process, use the removed plate cover to shield the test surface from the falling precipitation. Record the time of fluid application on the chosen data form.

6) After fluid application is complete, each test surface must be inspected periodically in order to assess the condition of the fluid layer. A section of the plate is considered failed when it is covered with frozen contamination. For Type I fluids, failure may occur quickly after fluid application.

7) If more than one-third of a given plate is determined to be "failed" (or if fluid failure is noted at any five of the crosshair marks on the plate), the plate as a whole is considered to be failed. Announce the fluid failure and ensure the failure time is recorded by the data form manager. Place a "poker chip" once failure has been declared to indicate that the plate is no longer running an active test.

8) Alternately, if a test reaches the maximum run time (representing the maximum allowable holdover time for the freezing precipitation condition being tested), the test can be stopped immediately. For freezing fog, the maximum run time is four hours. For all other simulated freezing precipitation conditions, that maximum run time is two hours. The data form manager must note that the test did not fail (typically by noting "Did Not Fail (DNF)" on the data form).

9) If there are no other tests currently running or immediately to be run on the position, reinstall the plate cover and signal the rate station manager to begin post-test rate collection cycles.

10) Prepare for the next condition.

5.4.3. Criteria for Validation of Fluid Endurance Time Test Results

Two data points must be collected with each dilution of each fluid being tested in a given condition. After both tests are complete, the endurance time results of the two

tests must be compared to confirm that they conform to the reproducibility criteria outlined in ARP5945A / ARP5845B.

The standard states that if the endurance time of one of the two tests lies outside ±10% from the average, then two additional data points must be collected with the fluid in question. In cases where additional data must be gathered, no data is to be discarded. All four data points will ultimately be used when analyzing the test results and determining fluid holdover times.

It is the responsibility of the testing manager to ensure that all results obtained conform to the reproducibility criteria, and that additional data is collected when the reproducibility criteria is not met. A spreadsheet was developed for quick verification of the reproducibility criteria; as matched pairs of tests are completed, their results should be entered into the spreadsheet for verification of conformance.

5.5. Fluid Film Thickness Testing

In addition to fluid endurance time testing, a standard simulated freezing precipitation endurance time test session will also include fluid film thickness testing for each dilution of each fluid being tested. This testing performed in the “small end” of the test chamber (away from the spray area) as no precipitation is required. The testing is performed at -3°C, and is generally run concurrently to fluid endurance time tests.

The steps for conducting fluid film thickness tests are summarized below.

1) Set up a full six-position test stand in the “small end” of the testing chamber (away from the spray area). The exact position of the test stand is not important, but ensure that the stand is levelled such that the test surfaces lie at a 10° angle (within 9.8° and 10.2° is acceptable, check each test surface). Equip the test stand with aluminum test plates.
2) Prepare the data form by recording the fluids to be poured in their respective positions.
3) Measure the initial fluid temperature of the fluids that are undergoing thickness testing. Unheated fluids (Types II, III-Unheated and IV) must be within 3°C (ideally 1°C) of -3°C. Heated fluids (Types I and III-Heated) must be within 5°C (ideally 1°C) of 20°C. If fluids are not at the correct temperature, warm them in the client area or cool them in a chest freezer as needed.
4) Pour 1L of each fluid onto the test surface from the top of the plate, ensuring that the entire surface of the plate is coated with an even fluid layer. Start recording time on a stopwatch after the first fluid is poured. Stagger each pour in order to ensure that all thickness measurements can

be captured at the appropriate times. Record the time of fluid application on the data form for each pour.

5) At the five minute mark (as noted on the stopwatch), measure the thickness of the first poured fluid layer along the six-inch line of the plate with a film thickness gauge. Confirm the measured value by taking a second reading at a different point along the six-inch line of the plate. If there is disagreement between the first and second thickness values, take a third measurement at another point along the six-inch line. If all three values are different, record all three values obtained. Otherwise, discard the non-conforming value.

6) Repeat the thickness measurement process for the other fluid layers, staggering the measurements in the same manner as the fluid application process, to ensure that each fluid film thickness is measured at its respective five minute mark. Record the measured fluid film thicknesses on the data form.

7) Repeat the thickness measurement process at the 15 minute mark, and again at the 30 minute mark. Ensure that all measurements are recorded for each fluid being tested.

5.6. Procedure for Cold Soaked Box Preparation

For rain on a cold-soaked wing endurance time testing, the test surface to be used is a leading edge thermal equivalent box filled with cold Type I fluid (known as a cold soaked box). As per ARP5945A and ARP5485B, the boxes must be prepared such that the surface temperature of the plate at the start time of an endurance time test is -10 ± 1°C.

The cold soaked box preparation should begin during the initial rate collection cycles of the cold-soaked wing condition in order to ensure that the surfaces are ready for testing as soon as the rate collection process is complete.

The steps for preparing cold soaked boxes for testing are listed below.

1) Close the large door in the test chamber, dividing the chamber into the large end (containing the spray area and the test stands) and the small end. Have the NRC personnel set the temperature of the small end of the chamber to -10°C.

2) Retrieve the containers of cold Type I fluid from the cold (-30°C) freezers and place in the small end of the chamber.

3) Using a combination of the cold Type I fluid jugs removed from the freezers and the warmer Type I fluid found in the barrel at the small end of the

chamber, prepare a large batch of Type I fluid with a fluid temperature of -12 ± 1°C. The Brix of the fluid mixture should fall between 26.00 and 29.00. Note that a very large volume of cold fluid is required to fill the boxes; the batch should be prepared in the largest container available on-hand. Mix the fluid frequently while preparing the batch and monitor the fluid temperature at all times during the box preparation process.

4) Place the empty cold soaked boxes and cold soaked box filling stand on the large metal table found in the small end of the testing chamber.

5) Place a box in the filling stand and fill with the prepared Type I fluid mixture. Once full, agitate the box within the stand to free any trapped air within. Refill the box and agitate once again, repeating the process until the box is completely full with no trapped air.

6) Close the box and verify that the surface temperature of the box is -11 ± 1°. Remove the box from the filling stand and place on a dolly to await transfer to the testing team for use.

7) Repeat the process with the remaining empty boxes. Note that the filled boxes are heavy – avoid placing too many on the dolly at one time.

8) As positions on the test stand become available for testing, the testing team will advise the box preparation team that filled boxes are needed. Transfer prepared boxes to the testing team as needed by raising the doors dividing the testing chamber and passing the dolly underneath. Avoid transferring boxes too early or transferring unneeded boxes, as the surface temperature of the filled boxes will change rapidly in the warmer end of the testing chamber.

9) As tests are completed, filled boxes that have been used by the testing team will be returned to the box preparation team. Empty the used boxes back into the prepared fluid mixture, ensuring that the temperature of the mixture remains at -12 ± 1°C.

10) Continue preparing boxes until a sufficient quantity has been prepared to complete all planned tests (as well as any supplemental tests required, as determined by the testing team).

11) At the end of the cold-soaked wing condition, return all Type I fluid to the barrel for future use.

5.7. End of Testing Day Activities

The steps for concluding a freezing precipitation endurance time testing day are summarized as follows:

1) Ensure all test surfaces are properly cleaned after testing and that all fluid within the collection pans is disposed of appropriately (all glycol waste must be vacuumed up and disposed of in the waste fluid tote);

2) Ensure that all fluids to be tested during the first condition planned for the following day are available and are stored at the proper temperature. Refill empty pour containers as needed;

3) Ensure copies of the rate station Excel outputs for each condition tested have been saved in the Data and Rates folder of the APS Test Site Dropbox;

4) If using the HOT Data Form app to record endurance times, export the data files for each condition tested and save copies in the Data and Rates folder of the APS Test Site Dropbox;

5) If using paper data forms, place the completed forms in an envelope and mark the envelope with the date and number of forms;

6) If it is the final testing day of the week, ensure that all Smart Button data from all test surfaces used is downloaded from the buttons and saved to the APS Test Site Dropbox;

7) If it is the final testing day of the session, ensure that the chamber temperature, relative humidity and video data is obtained from the NRC personnel.

8) Ensure that the Dropbox program is synced and that all saved files have been uploaded; and

9) Confirm starting time for the next testing day with all APS/NRC personnel prior to leaving for the day.

6. EQUIPMENT

The equipment required for endurance time testing in simulated freezing precipitation is listed in Attachment 2. The specific equipment needed for each session is listed in the annual NRC procedure.

7. PERSONNEL

Generally, five to six people are required for simulated freezing precipitation endurance time testing:

1) Testing Manager – responsible for overseeing the test event, determining which tests are to be run, applying fluids and calling all failures;

2) Rate Station Manager – responsible for overseeing the rate collection process and coordinating the testing assistants assigned to the rate station;

3) Data Form Manager – responsible for managing all data forms (paper and electronic) and ensuring all information is properly transcribed and captured; and

4) Testing Assistants (2 or 3) – responsible for set-up activities, rate collection, clean-up and assisting with any other tasks as determined by the testing manager.

Note that for simulated freezing precipitation testing, the testing assistants are generally part-time personnel who are based in the Ottawa area.

8. SAFETY

Testing in cold temperatures can pose significant safety issues. Jackets, gloves and boots should be rated to very low temperatures and must be worn at all times when inside the testing chamber. Employees should be mindful of dangers associated with hypothermia and frostbite.

Additionally, as all simulated freezing precipitation testing takes place at an NRC controlled facility, all employees must adhere to any and all safety guidelines imposed by the NRC or its personnel.

9. DATA FORMS AND SOFTWARE

The following data forms and software are typically used for simulated freezing precipitation endurance time testing:

1) Rate Station Software;

2) General Session Conformance Checklist (Attachment 1)

3) NRC Continuous Rate Form (Attachment 3);

4) End Condition Data Form for Endurance Time Tests – used as backup for app data form (Attachment 4);

5) App Data Form for Fluid Endurance Time Tests (Attachment 5); and

6) Fluid Film Thickness Testing Data Form (Attachment 6)

Attachment 1: General Session Conformance Checklist

LOCATION: CEF (Ottawa) **DATE:**

Safety Issues Discussed ☐

Test Plate Material: ☐
(check the box if material used is Aluminum alloy AMS 4037)

Test Plate Dimensions: ☐
(check the box if the dimensions are 500mm long x 300mm wide x 3.2mm thick)

Test Box Dimensions: ☐
(only for CSW, check the box if the dimensions are 500mm long x 300mm wide x 75mm thick)

Surface Finish: ☐
(check the box if the average surface roughness is ≤ 0.5 µm)

Ice-catch Pan Dimensions: ☐
(check the box if the dimensions are 406mm long x 279mm wide with a 64mm height)

Water Supply to Nozzle: ☐
(check the box if the water supplied to the nozzles conforms to is ASTM D1193 Type IV water or a hardness of less than 300 ppm reported as $CaCO_3$)

Weigh Scale Verification ☐
(check the box if calibration was performed in the previous summer)

Distance between Nozzle and Test Plates ☐
(check the box if distance is 7±0.5, for ZD, ZR and CSW)

Distance between Temperature Sensor and Test Plates ☐
(check the box if distance is within 1.5m)

COMMENTS:

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.....

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LEADER: _____

Attachment 2: Equipment List for Simulated Freezing Precipitation Testing

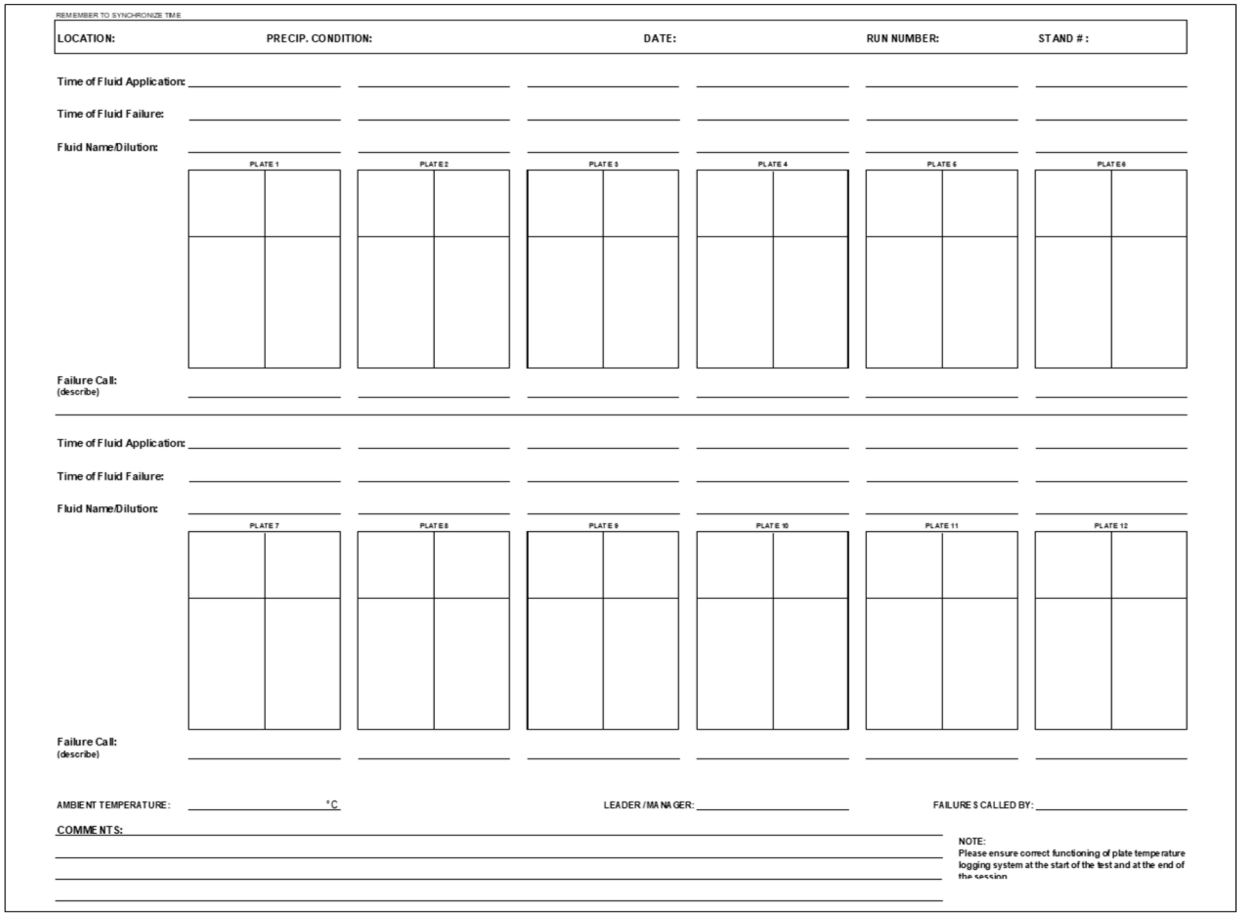
SIMULATED FREEZING PRECIPITATION TESTING	
LOCATION: TEST SITE	
Barrel Opener to open CSW fluids	Power bars x 4
Bins for mixing CSW fluid x 5 (60L rubbermaids)	Printer & Ink Cartridge
Brixometer x 3	Rain Suits (all)
Camera x1 (small Canon) with accessories	Rate Pan (aluminum HOT) x1
Cart (IKEA) x2	Rate Pans(white plastic) x all
Clipboards x 5	Sample bottles x 6
Clock (Large digital) x 2	Scrapers x 14
Cold-soak boxes (aluminum) x 16	Shop Vac + 2x18L open top pails
Extension Cords x 4	Smart button kits x 2 + extension wire
Flashlights x 2	Speed tape x 1 and electrical tape x 5
Fluids (separate table)	Squeegees x 4 (small)
Folding table x 1 (small)	Tape measure (large yellow + small)
Freezers (portable) x2	Temperature probes: immersion x 3
Funnels x 4 (big and small)	Temperature probes: surface x 3
Gloves - black and yellow x4	Test plate covers (white plastic) x 15
Gloves - cotton (1 large box)	Test plate covers (wooden boards) x 12
Gloves - latex (2 boxes)	Test Plates - Half plates x 11 (22 halves) w/buttons
Ice Pic	Test Plates (Aluminum): 12 w/buttons + 6 w/out
Inclinometer (yellow level) x 2	Test Stand Collection Pans (one per stand)
Isopropyl x 15	Test Stand Shims (poker chips) x 1 box
Jigaloo x1 and Scotchguard x1	Test Stands: 1 x 6 position (small end)
Lock for truck	Test Stands: 2 x 6-position (main stand)
Marker for Waste x 2	Test Stands: 3 position (side stand) (2+1)
Measuring Cups x 3	Thickness Gauges (4 x small 4 x large)
Pails x 5 (Empty 18L cont. for -30C CSW fluid)	Tuques x10
Paper Towels (4 packs)	Vise grip (large) + rubber opener
Personnel clothing + SB box	Weigh Scale x 2 (sartorius) + wiring
Pour containers (1-litre) - 6 empty	White poster board panels for water run-off
Pour containers (1-litre) - see list of fluids	Yellow Carrying Cases x4
LOCATION: OFFICE	
Blank Waterproof labels (1 page)	Laptop for smart button (MR)
Coffee x 140 (K-Cups)	Laptop x5 (CB, SB, JD, BB, Rate Station)
Condition Sheets x 6	Mouse for Rate Station and keypad
Data Forms (on water phobic paper)	Paper for printer (1 pack)
Envelopes (9x12) x box	Pencils (sharpened) + pens + markers
Falling Ball Viscometer + Syringes	Test Procedures x 6
File Box (for forms, procedures, etc.)	Walkie Talkies x 4
Hard Drive (if necessary)	Waterproof paper (40 sheets)
iPads x 3	

SIMULATED FREEZING PRECIPITATION TESTING	
LOCATION: NRC	
Cold-soak box filling stand	Rubber Mats
Cold-soak fluid pump	Shelving unit x 1 (black one)
Copper tubing insulation (for passing wires)	Tie wraps
Fluid for cold-soak boxes (barrel)	Tools
NRC Auto Rate Form with Historical #'s	Tote for Waste Fluid

Attachment 3: NRC Continuous Rate Form

Condition	Date	Historical Average Calculated Rate - Position 1	Standard Deviation of Historical Average Calculated Rate (Pos. 1) Between Sessions	Historical Average of Session Standard Deviation During Session	Start Position Stand 1 (X_1, Y_1) Stand 2 (X_2, Y_2) (For ZF, coordinates are nozzle position)	Condition Difficulty Rating (1-5, 1 is easiest)	Historical Condition Difficulty Rating (1-5, 1 is easiest)	Comments
ZF, -3, 2		1.8	0.3	0.7	Pos. 10 (2'',0'')		1.3	
ZF, -3, 5		4.9	0.6	2.1	Pos. 4 (0'', 18'')		2.7	
ZF, -10, 2		1.9	0.3	0.6	Pos. 10 (2'',0'')		1.0	
ZF, -10, 5		4.9	1.0	0.9	Pos. 10 (2'',0'')		1.5	
ZF, -14, 2		2.1	0.2	0.7	Pos. 10 (2'',0'')		1.3	
ZF, -14, 5		4.8	0.3	1.1	Pos. 10 (2'',0'')		1.3	
ZF, -25, 2		2.0	0.4	1.0	Pos. 10 (2'',0'')		1.0	
ZF, -25, 5		4.8	0.4	1.2	Pos. 10 (2'',0'')		2.7	
ZF, -35, 2		2.1	0.1	1.0	Pos. 10 (2'',0'')		2.7	
ZF, -35, 5		5.1	0.0	1.5	Pos. 10 (2'',0'')		3.0	
ZD, -3, 5		5.5	0.2	0.9	(23' 11'', 7'), (24' 9'')		3.0	
ZD, -3, 13		13.0	1.8	1.7	(23' 11'', 6'10''), (24' 9'')		3.0	
ZD, -6, 5		n/a	n/a	n/a	n/a		n/a	
ZD, -6, 13		n/a	n/a	n/a	n/a		n/a	
ZD, -10, 5		5.9	0.4	0.8	(23' 11'', 6'7''), (24' 9'')		1.0	
ZD, -10, 13		14.0	0.5	1.7	(23' 11'', 6'7''), (24' 9'')		2.3	
ZR, -3, 13		13.6	0.5	1.2	(23' 11'', 6'7''), (24' 9'')		2.3	
ZR, -3, 25		25.7	0.6	1.5	(23' 11'', 6'7''), (24' 9'')		1.0	
ZR, -6, 13		n/a	n/a	n/a	n/a		n/a	
ZR, -6, 25		n/a	n/a	n/a	n/a		n/a	
ZR, -10, 13		13.9	0.7	1.0	(23' 11'', 6'7''), (24' 9'')		3.7	
ZR, -10, 25		26.1	0.5	1.2	(23' 11'', 6'7''), (24' 9'')		1.0	
CS, 1, 5		4.9	0.2	4.0	(23' 11'', 6'10''), (24' 9'')		2.3	
CS, 1, 75		75.6	3.4	13.1	(23' 11'', 6'10''), (24' 9'')		3.0	

Attachment 4: End Condition Data Form for Endurance Time Tests



REMEMBER TO SYNCHRONIZE TIME

LOCATION: PRECIP. CONDITION: DATE: RUN NUMBER: STAND # :

Time of Fluid Application:

Time of Fluid Failure:

Fluid Name/Dilution:

PLATE 1 PLATE 2 PLATE 3 PLATE 4 PLATE 5 PLATE 6

Failure Call:
(describe)

Time of Fluid Application:

Time of Fluid Failure:

Fluid Name/Dilution:

PLATE 7 PLATE 8 PLATE 9 PLATE 10 PLATE 11 PLATE 12

Failure Call:
(describe)

AMBIENT TEMPERATURE: °C LEADER / MANAGER: FAILURES CALLED BY:

COMMENTS:

NOTE:
Please ensure correct functioning of plate temperature logging system at the start of the test and at the end of the session

Attachment 5: Screenshot of Holdover Time Data Form App

Attachment 6: Fluid Film Thickness Testing Data Form

REMEMBER TO SYNCHRONIZE TIME

LOCATION: DATE: TEMPERATURE °C: RUN NUMBER(S): TEST # : to

Time of Fluid Application: _____ _____ _____ _____ _____ _____

Fluid Name/Dilution: _____ _____ _____ _____ _____ _____

RUN #: _____

PLATE 1		PLATE 2		PLATE 3		PLATE 4		PLATE 5		PLATE 6	
TIME (min)	THICKNESS 6" LINE	TIME (min)	THICKNESS 6" LINE	TIME (min)	THICKNESS 6" LINE	TIME (min)	THICKNESS 6" LINE	TIME (min)	THICKNESS 6" LINE	TIME (min)	THICKNESS 6" LINE

Time of Fluid Application: _____ _____ _____ _____ _____ _____

Fluid Name/Dilution: _____ _____ _____ _____ _____ _____

RUN #: _____

PLATE 1		PLATE 2		PLATE 3		PLATE 4		PLATE 5		PLATE 6	
TIME (min)	THICKNESS 6" LINE	TIME (min)	THICKNESS 6" LINE	TIME (min)	THICKNESS 6" LINE	TIME (min)	THICKNESS 6" LINE	TIME (min)	THICKNESS 6" LINE	TIME (min)	THICKNESS 6" LINE

PERFORMED BY: _____ WRITTEN BY: _____

COMMENTS: _____

NOTES:

- The quantity of fluid that will be poured for each test is 1.0 L on a full plate or 0.5L on a half plate
- Measurements should be made at the 6-inch line at the time of fluid application, and after 5 minutes, 15 minutes, and 30 minutes.
- If the results for one fluid vary by more than 10% repeat the two tests and disregard the highest and lowest values

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APPENDIX D

2021-2022 MIXED ICING RESEARCH – TEST DATA

2021-2022 MIXED ICING RESEARCH – TEST DATA

This appendix contains the data from the snow-only baseline testing collected as part of the mixed snow and freezing fog endurance time testing project conducted at the National Research Council Canada (NRC) Climatic Engineering Facility (CEF) in 2021-22.

Table 1 describes the headings found within the test log. Table 2 contains the relevant test data.

Table 1: Description of Column Headings in the NRC CEF Testing Log

Column Heading	Description
Test #	The number identifying the test run.
Date	The date when the test was conducted.
Fluid Name	The name of the anti-icing fluid used during the test.
Fluid Type	The type of the anti-icing fluid used during the test.
Test Surface	The material of which the test surface is composed.
Condition	The precipitation type(s) being simulated during the test.
Temp. (°C)	The chamber temperature setting during the test.
Target Snow Rate (g/dm²/h)	The targeted rate of snow precipitation for the test.
Actual Snow Rate (g/dm²/h)	The measured rate of the snow precipitation for the test.
Actual Rate (Combined)	The measured rate of the snow and freezing fog components of the precipitation combined.
Endurance Time (min)	The measured endurance time of the test.

Table 2: 2022-23 Mixed Snow and Freezing Fog Project - Snow Baseline Tests

Test #	Date	Fluid Name	Fluid Type	Test Surface	Condition	Temp. (°C)	Target Snow Rate (g/dm²/h)	Actual Snow Rate (g/dm²/h)	Endurance Time (min)
167	Mar 3, 2022	Clariant Safewing MP II FLIGHT	II	Aluminum	Light Snow	-3	10	10	87.8
168	Mar 3, 2022	Clariant Safewing MP II FLIGHT	II	Aluminum	Light Snow	-3	10	10	97.5
175	Mar 3, 2022	AllClear AeroClear MAX	III	Aluminum	Light Snow	-3	10	10	53.0
176	Mar 3, 2022	AllClear AeroClear MAX	III	Aluminum	Light Snow	-3	10	10	58.5
187	Mar 3, 2022	Cryotech Polar Guard Advance	IV	Aluminum	Light Snow	-3	10	10	167.8
188	Mar 3, 2022	Cryotech Polar Guard Advance	IV	Aluminum	Light Snow	-3	10	10	177.7
195	Mar 3, 2022	Dow EG106	IV	Aluminum	Light Snow	-3	10	10	130.3
196	Mar 3, 2022	Dow EG106	IV	Aluminum	Light Snow	-3	10	10	127.1
219	Mar 3, 2022	Clariant Safewing MP II FLIGHT	II	Aluminum	Moderate Snow	-3	25	24.9	26.7
220	Mar 3, 2022	Clariant Safewing MP II FLIGHT	II	Aluminum	Moderate Snow	-3	25	24.9	28.1
227	Mar 2, 2022	AllClear AeroClear MAX	III	Aluminum	Moderate Snow	-3	25	25	27
228	Mar 2, 2022	AllClear AeroClear MAX	III	Aluminum	Moderate Snow	-3	25	25	24
229	Mar 2, 2022	AllClear AeroClear MAX	III	Aluminum	Moderate Snow	-3	25	25	24
230	Mar 2, 2022	AllClear AeroClear MAX	III	Aluminum	Moderate Snow	-3	25	25	24
231	Mar 2, 2022	AllClear AeroClear MAX	III	Aluminum	Moderate Snow	-3	25	25	24
232	Mar 2, 2022	AllClear AeroClear MAX	III	Aluminum	Moderate Snow	-3	25	25	24
233	Mar 2, 2022	AllClear AeroClear MAX	III	Aluminum	Moderate Snow	-3	25	25	25
234	Mar 2, 2022	AllClear AeroClear MAX	III	Aluminum	Moderate Snow	-3	25	25	25
235	Mar 2, 2022	AllClear AeroClear MAX	III	Aluminum	Moderate Snow	-3	25	25	25

Table 2: 2022-23 Mixed Snow and Freezing Fog Project - Snow Baseline Tests (cont'd)

Test #	Date	Fluid Name	Fluid Type	Test Surface	Condition	Temp. (°C)	Target Snow Rate (g/dm²/h)	Actual Snow Rate (g/dm²/h)	Endurance Time (min)
236	Mar 2, 2022	AllClear AeroClear MAX	III	Aluminum	Moderate Snow	-3	25	25	25
237	Mar 2, 2022	AllClear AeroClear MAX	III	Aluminum	Moderate Snow	-3	25	25	25
238	Mar 2, 2022	AllClear AeroClear MAX	III	Aluminum	Moderate Snow	-3	25	25	27
239	Mar 2, 2022	AllClear AeroClear MAX	III	Aluminum	Moderate Snow	-3	25	25	23
240	Mar 2, 2022	AllClear AeroClear MAX	III	Aluminum	Moderate Snow	-3	25	25	20
241	Mar 2, 2022	AllClear AeroClear MAX	III	Aluminum	Moderate Snow	-3	25	25	24
242	Mar 2, 2022	AllClear AeroClear MAX	III	Aluminum	Moderate Snow	-3	25	25	20
243	Mar 2, 2022	AllClear AeroClear MAX	III	Aluminum	Moderate Snow	-3	25	25	23
244	Mar 2, 2022	AllClear AeroClear MAX	III	Aluminum	Moderate Snow	-3	25	25	20
245	Mar 2, 2022	AllClear AeroClear MAX	III	Aluminum	Moderate Snow	-3	25	25	24
246	Mar 2, 2022	AllClear AeroClear MAX	III	Aluminum	Moderate Snow	-3	25	25	22
247	Mar 2, 2022	AllClear AeroClear MAX	III	Aluminum	Moderate Snow	-3	25	25	20
248	Mar 2, 2022	AllClear AeroClear MAX	III	Aluminum	Moderate Snow	-3	25	25	20
249	Mar 2, 2022	AllClear AeroClear MAX	III	Aluminum	Moderate Snow	-3	25	25	24
250	Mar 2, 2022	AllClear AeroClear MAX	III	Aluminum	Moderate Snow	-3	25	25	23
251	Mar 3, 2022	AllClear AeroClear MAX	III	Aluminum	Moderate Snow	-3	25	24.9	27.6
252	Mar 3, 2022	AllClear AeroClear MAX	III	Aluminum	Moderate Snow	-3	25	24.9	31.3
253	Mar 3, 2022	Cryotech Polar Guard Advance	IV	Aluminum	Moderate Snow	-3	25	24.9	43.2
254	Mar 3, 2022	Cryotech Polar Guard Advance	IV	Aluminum	Moderate Snow	-3	25	24.9	46.1

Table 2: 2022-23 Mixed Snow and Freezing Fog Project - Snow Baseline Tests (cont'd)

Test #	Date	Fluid Name	Fluid Type	Test Surface	Condition	Temp. (°C)	Target Snow Rate (g/dm²/h)	Actual Snow Rate (g/dm²/h)	Endurance Time (min)
261	Mar 3, 2022	Dow EG106	IV	Aluminum	Moderate Snow	-3	25	24.9	78.9
262	Mar 3, 2022	Dow EG106	IV	Aluminum	Moderate Snow	-3	25	24.9	68.5
285	Mar 10, 2022	Clariant Safewing MP II FLIGHT	II	Aluminum	Light Snow	-14	10	13.7	46.3
293	Mar 10, 2022	AllClear AeroClear MAX	III	Aluminum	Light Snow	-14	10	13.7	90.8
301	Mar 10, 2022	Cryotech Polar Guard Advance	IV	Aluminum	Light Snow	-14	10	13.7	71.9
302	Mar 10, 2022	Cryotech Polar Guard Advance	IV	Aluminum	Light Snow	-14	10	13.7	66.0
309	Mar 10, 2022	Dow EG106	IV	Aluminum	Light Snow	-14	10	13.7	113.0
310	Mar 10, 2022	Dow EG106	IV	Aluminum	Light Snow	-14	10	13.7	132.0
333	Mar 9, 2022	Clariant Safewing MP II FLIGHT	II	Aluminum	Moderate Snow	-14	25	30.9	22.2
341	Mar 9, 2022	AllClear AeroClear MAX	III	Aluminum	Moderate Snow	-14	25	30.9	43.8
349	Mar 9, 2022	Cryotech Polar Guard Advance	IV	Aluminum	Moderate Snow	-14	25	30.9	22.3
350	Mar 9, 2022	Cryotech Polar Guard Advance	IV	Aluminum	Moderate Snow	-14	25	30.1	26.7
357	Mar 9, 2022	Dow EG106	IV	Aluminum	Moderate Snow	-14	25	30.9	70.0
358	Mar 9, 2022	Dow EG106	IV	Aluminum	Moderate Snow	-14	25	30.9	72.2
381	Mar 14, 2022	Clariant Safewing MP II FLIGHT	II	Aluminum	Light Snow	-25	10	10.3	38.7
389	Mar 14, 2022	AllClear AeroClear MAX	III	Aluminum	Light Snow	-25	10	10.3	98
397	Mar 14, 2022	Cryotech Polar Guard Advance	IV	Aluminum	Light Snow	-25	10	10.3	38.2
398	Mar 14, 2022	Cryotech Polar Guard Advance	IV	Aluminum	Light Snow	-25	10	10.3	38.2
405	Mar 14, 2022	Dow EG106	IV	Aluminum	Light Snow	-25	10	10.3	93.1

Table 2: 2022-23 Mixed Snow and Freezing Fog Project - Snow Baseline Tests (cont'd)

Test #	Date	Fluid Name	Fluid Type	Test Surface	Condition	Temp. (°C)	Target Snow Rate (g/dm²/h)	Actual Snow Rate (g/dm²/h)	Endurance Time (min)
406	Mar 14, 2022	Dow EG106	IV	Aluminum	Light Snow	-25	10	10.3	91.5
429	Mar 14, 2022	Clariant Safewing MP II FLIGHT	II	Aluminum	Moderate Snow	-25	25	29	12.8
437	Mar 14, 2022	AllClear AeroClear MAX	III	Aluminum	Moderate Snow	-25	25	29	48.0
445	Mar 14, 2022	Cryotech Polar Guard Advance	IV	Aluminum	Moderate Snow	-25	25	29	12.8
446	Mar 14, 2022	Cryotech Polar Guard Advance	IV	Aluminum	Moderate Snow	-25	25	29	16.0
453	Mar 14, 2022	Dow EG106	IV	Aluminum	Moderate Snow	-25	25	29	33.0
454	Mar 14, 2022	Dow EG106	IV	Aluminum	Moderate Snow	-25	25	29	31.3
219A	Mar 8, 2022	Clariant Safewing MP II FLIGHT	II	Aluminum	Moderate Snow	-3	25	29.2	32.8
227A	Mar 8, 2022	AllClear AeroClear MAX	III	Aluminum	Moderate Snow	-3	25	29.2	23.5
253A	Mar 8, 2022	Cryotech Polar Guard Advance	IV	Aluminum	Moderate Snow	-3	25	29.2	39.0
254A	Mar 8, 2022	Cryotech Polar Guard Advance	IV	Aluminum	Moderate Snow	-3	25	29.2	41.0
261A	Mar 8, 2022	Dow EG106	IV	Aluminum	Moderate Snow	-3	25	29.2	63
262A	Mar 8, 2022	Dow EG106	IV	Aluminum	Moderate Snow	-3	25	29.2	57

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